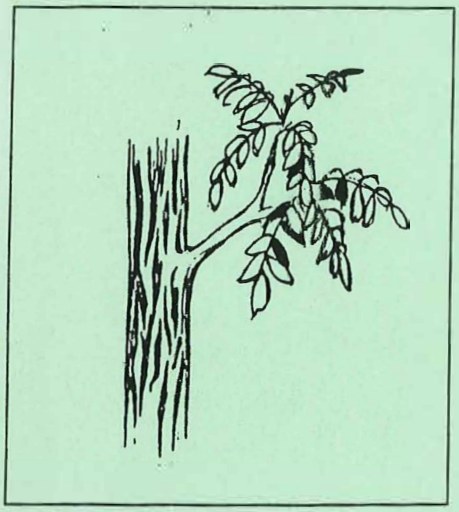

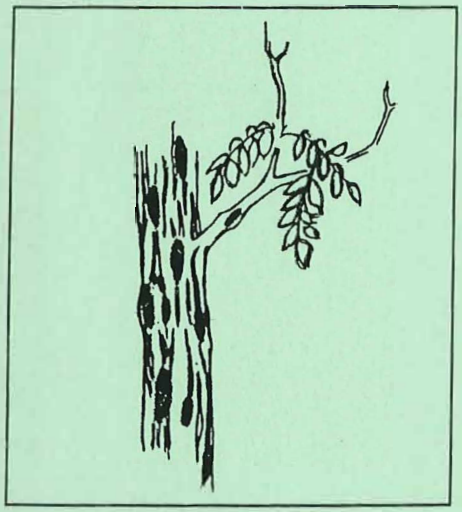

# FOREST HEALTH CONDITIONS IN WISCONSIN

# ANNUAL REPORT 1998

Wisconsin Department of
Natural Resources
PO Box 7921
Madison, WI 53707

# FOREST HEALTH CONDITIONS IN WISCONSIN

## CALENDAR YEAR 1998

[1]


**PREPARED BY**

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**WISCONSIN DEPARTMENT OF NATURAL RESOURCES**

**FOREST HEALTH PROTECTION UNIT**


[1] Illustrations of butternut canker on front cover and this page by David Kopitzke, Landowner Contact Specialist, Bureau of Endangered Resources, Wisconsin Department of Natural Resources.

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# INTRODUCTION

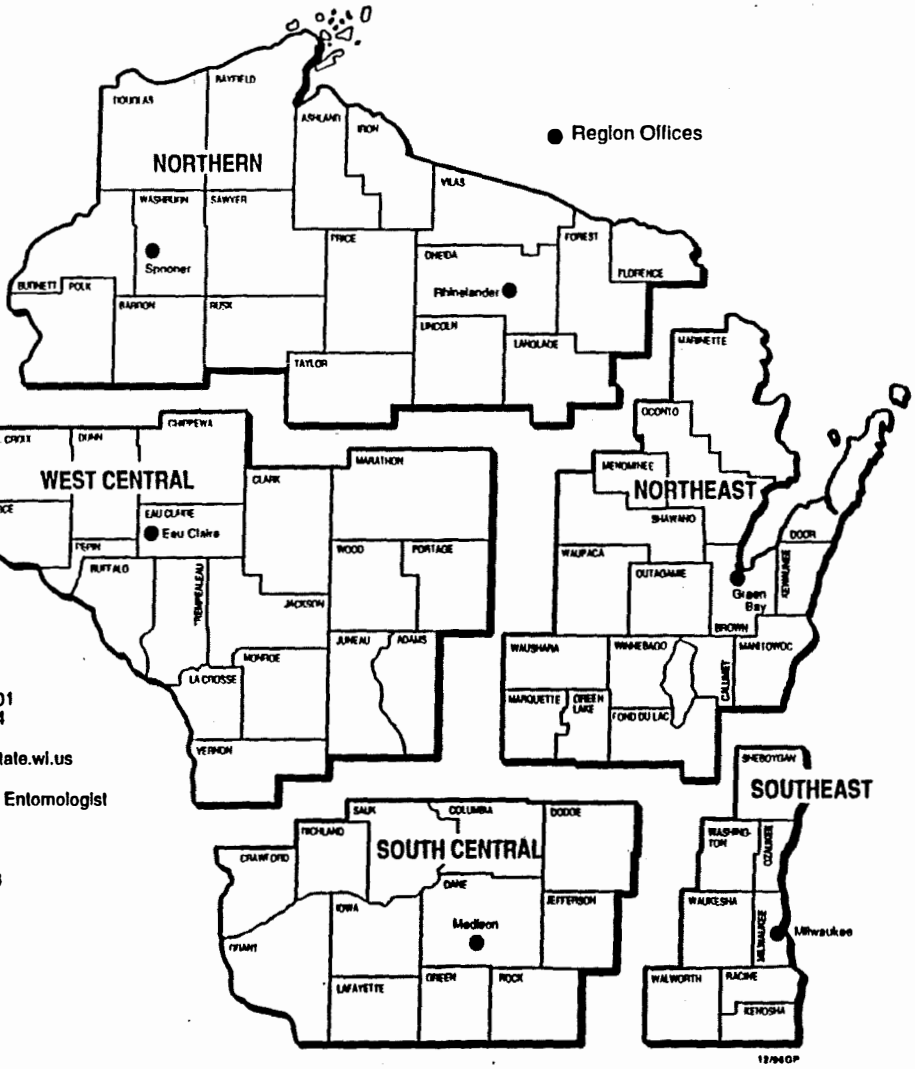


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Figure 1. Locations of DNR forest pest specialists and their regional territories – December 1998.

# WISCONSIN FOREST HEALTH HIGHLIGHTS – 1998

(as seen on the world wide web at: http://willow.ncfes.umn.edu/fhh-98/wi_98.htm)

The Forest Health Protection Unit and regional forest pest specialists provided a wide variety of programs and information on forest pests, and continued to teach integrated pest management principles to DNR foresters, industrial foresters, and private woodland owners. They successfully educated about 4,500 individuals at 79 different training sessions. At the same time, insect and disease detection surveys were conducted on approximately 9.6 million acres, and evaluation surveys on 1.8 million acres.

## The Resource

The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16 million acres, representing 46 percent of the total land area. The state now has the most forestland it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84 percent of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state is maple-basswood, which makes up 5.3 million acres (34%) of Wisconsin's timberland area. Conifer types represent 16 percent of the total timberland area (pine forests - 8%, spruce-fir - 6%, and swamp conifers - 2%).

Forests are important to the economy of Wisconsin, not only in the form of wood products, but also in the form of recreation and tourism. The primary and secondary wood products industry is the second largest employer in the state. These industries put Wisconsin first in the nation in the production of fine paper, sanitary paper products, children's furniture, and millwork. The value of shipment of these products annually exceeds $19.7 billion. Forest and water resources in Wisconsin are a primary tourism attraction for both residents and visitors. The variety of Wisconsin's forest ecosystems support a great diversity of wildlife species, while recreational use of forests continues to grow and expand.

## Special Issues

This year, the **gypsy moth** spray program treated 61 sites, for a total of 34,711 acres in 20 counties. The bacterial insecticide, Btk was applied twice, at one-week intervals, to all sites in mid May. The majority of the acreage sprayed was in Portage, Waushara, and Wood counties. In late June, two more sites in Jefferson and Sauk counties were treated to slow the spread of the gypsy moth. Instead of Btk, however, flakes containing the female pheromone were distributed by plane over parts of Devil's Lake State Park and the Southern Unit of Kettle Moraine State Forest.

Results from this year's trapping season revealed a total of 108,704 moths trapped from approximately 45,000 delta traps throughout the state. The total number of moths caught is a reflection of both DATCP and cooperator data.

Introductions of biological controls made in October 1997 were followed up this summer. The fungus *Entomophaga maimaiga* was introduced into 22 sites in eastern WI. It has been confirmed that *E. maimaiga* has become established at an introduction site in Oconto, WI. At three sites in northeastern WI, the parasitic wasp *Cotesia melanoscela* was released.

No change was observed in the county distribution of **oak wilt** in 1998. Surveys were conducted in northeastern Wisconsin in Marathon, Marinette, Menominee, and Shawano counties. No significant movement north was noted, but new pockets in all of these counties were observed. On a similar note, **oak twig girdler** was widespread on northern pin oak and black oak in northwest and central Wisconsin this August. Damage from this pest was often confused for oak wilt symptoms. The **jumping oak gall** caused injury to buds of burr oak and white oak in southern Wisconsin in May. Trees failed to leaf out in late May and early June, but did refoliate two to three weeks later.

The fourth year of a five-year survey of oak wilt was conducted to determine the relationship between pruning of oak conducted by Alliant (formerly Wisconsin Power & Light) and the overland spread of oak wilt. Surveys were concentrated in Columbia County. This project will continue in 1999 and a summary report will be written at the survey's conclusion. A committee entitled *Oak Wilt Management in Communities*, composed of private citizens and individuals in local and state government and private business worked together to create a model ordinance for oak wilt control. Copies of the model ordinance will be available in 1999 through DNR urban forestry specialists and forest health specialists. The committee is also developing a web site for oak wilt, which will be maintained by the USDA Forest Service.

A cooperative project between the USDA Forest Service, University of Wisconsin, and WI, MI and MN DNR's, was initiated to determine the current **health status of basswood** in selected areas of the state. The project was initiated in response to an observed change in the crown density and dieback of basswood in Michigan. Efforts in 1998

concentrated on sampling basswood for various insect pests. Data was also collected on crown health, and the presence of any other damaging agents were noted. This project will continue through 1999 and possible through the year 2000.

**Introduced basswood thrips** caused moderate defoliation in northwestern Wisconsin in 1998. Damage covered approximately 9,700 acres in Bayfield, Polk, Rusk, Sawyer, and Washburn counties.

Efforts on **butternut canker** continued to be focused on collection of scion wood from potentially disease resistant butternuts. Scions were collected from a stand in Rock County and one in Winnebago County. Scions were sent to the USDA Forest Service for grafting to the root stock of black walnut seedlings. Seedlings were planted into orchards in MN and WI and will be tested for their ability to resist infection.

On May 31, a "derecho" or widespread, straight-line wind event moved through parts of southcentral and southeast Wisconsin - the most damaging straight-line wind event to hit Wisconsin in 100 years. Hurricane-like winds, with gusts up to 100 mph, ripped through 12 counties in that part of the state. Thousands of large trees were uprooted, twisted, broken off, and downed by the winds.
Again, on June 27, high winds ripped through Buffalo, Jackson, Monroe, and Trempealeau counties, damaging nearly 100,00 acres of forested land. About 3,000 acres of previously thinned red pine plantations were snapped off, flattened, or bent. Oaks and other hardwoods were tipped or broken off. Cleanup and salvage operations began in July and DNR foresters still continue to deal with the storm damage. The Ips bark beetle moved in rapidly and attacked damaged pines in early July.

## Other Issues

The **Columbian timber beetle** was found in Dane County on bur oak in September 1998. While it may have previously existed here at low numbers, it has never been recorded in Wisconsin before. It attacks a variety of hardwood species, especially silver and red maple, and oak in some areas. Damage is limited to the staining of wood in characteristic patterns, which causes a reduction in the grade of hardwood lumber. Gallery entrances heal over and decay fungi seldom enter. Because the beetle attacks healthy trees, mortality is seldom associated with outbreaks.

The **lesser maple spanworm**, which defoliates red maple in late spring, occurs in the eastern United States and Canada. This inchworm is native to Wisconsin, but before 1998 it had not been reported to cause noticeable defoliation. This year in Sauk County, understory saplings were completely defoliated, while mature trees were lightly to heavily defoliated. The defoliation pattern was spotty, with individual trees heavily defoliated and adjacent trees nearly untouched. Pockets of heavily defoliated trees often occurred near the center of the outbreak area between Plain and Natural Bridge State Park.

**Asian longhorned beetle** (ALB) infestations have recently been reported in Illinois, and have generated considerable interest in Wisconsin. Three locations have been quarantined in the Chicago area since the first infestation was reported in early July. USDA - APHIS suspects that the beetles were transported from Asia in shipments that use wooden crates and pallets. In southern Wisconsin, a beetle found inside a warehouse three years ago was identified as ALB. Currently, no infestation on trees in Wisconsin has been reported, although the beetle could pose a serious threat since many Asian goods are coming into Wisconsin.
Unlike most native long-horned beetles, Asian long-horned beetles can attack and kill healthy, mature hardwood trees. Known hosts are maple (especially silver and Norway maples), boxelder, horsechestnut, willow, poplar, birch, rose of Sharon, and ash. At this point, the control strategy in Wisconsin is to conduct a thorough search for symptoms, but to avoid disturbing adult beetles, which might cause them to disperse. Trees with symptoms will be cut, chipped, and burned during the dormant season.

A recently discovered **pitch midge** on white pine Christmas trees has the potential to become a pest, but the severity of the problem in Wisconsin is not predictable. This white pine pitch midge is native to North America and has probably been in Wisconsin all along, but never numerous enough to be noticed. The biology and potential damage of this pitch midge is largely unknown. They appear to inhabit pitch masses that ooze from wounds caused by physical damage. It is unclear whether they can initiate a wound or if they cause increased pitch flow in existing wounds. Currently, the only confirmed location of white pine pitch midge in Wisconsin is in Jackson County.

Various **broadleaf defoliators** were observed in northern Wisconsin in 1998. Aspen blotch miner caused moderate to severe damage in Langlade, Lincoln, and Oneida counties. Oak webworm defoliated 2,000 acres of oak in the Minong

area in Washburn County, as well as in Oneida County. Trembling aspen was severely defoliated by large aspen tortrix in Oneida County. For the first time in several years, bruce spanworm defoliated sugar maple in Florence and Forest counties. The only previous outbreak in Wisconsin occurred from 1984-1987 in the same area - little maple damage resulted.

**Conifer pests** included: jack pine budworm defoliation in Adams and Juneau counties, spruce budworm defoliation of white spruce in Marathon County, pine spittlebug on jack and red pines in Oneida and Vilas counties, and red pine needle midge present on 1,500 acres in Burnett and Washburn counties.

Due to the mild winter, followed by the long growing season this year, there was an abundance of multicolored **Asian lady beetles** throughout the state. This swarm resulted in numerous calls about the beetles invading homes.

A survey of white pine in Wisconsin is currently underway to document the incidence of stem cankers due to **white pine blister rust**. The study focuses on pole and small sawtimber stands in Risk Zone 4 of northern Wisconsin. The main objective is to evaluate the current status of older stands that may have undergone high infection as seedlings/saplings.

## Regional Issues

Efforts to detect changes in forest health on a regional (Lake States) basis continues through data collection on permanent plots - 89 for Forest health Monitoring (FHM) and 18 for North American Maple Project (NAMP). In addition to visiting all plots on the ground, all 18 NAMP plots were observed from the air in an attempt to detect major outbreaks of spring defoliators. No widespread defoliation of sugar maple was detected on these plots in 1998. Data for both of these plot programs centers on monitoring crown conditions, including dieback, foliage transparency, and crown density.

# ALERTS

**Forest insects and diseases that are new or of special interest.**
**If you observe any of these, contact your local forest pest specialist.**

## Asian Longhorned Beetle - *Anoplophora glabripennis*

The Asian longhorned beetle (ALB) caused a craze in the Midwest in 1998. Infestations were discovered in Chicago in early July, where three locations were quarantined. In southern Wisconsin, a dead beetle found in a warehouse three years ago was identified as ALB; however, extensive surveys revealed no sign of infestation in that area. The United States Dept. of Agriculture – Animal and Plant Health Inspection Service (USDA–APHIS) suspects that the beetles were transported from Asia in shipments that use wooden crates and pallets.

The ALB will attack many species of North American hardwood trees. It prefers maple, boxelder, poplar and willow, but occasionally will attack black locust, ash and oak. Unlike most native longhorned beetles, ALB can attack and kill healthy, mature trees. It therefore poses a threat to Wisconsin's forest resource, where it could potentially cause enormous damage. Since removal of infested trees is currently the only option to prevent further infestation, early detection is the key to minimizing damage by this beetle.

The responsible agencies, USDA–APHIS and WI DATCP, are cooperating with the US Forest Service and DNR to locate and inspect potential infestation sites near suspect shipping locations. The current control strategy is to visually detect evidence of the beetles and mark individual infested trees. If infested trees are treated while adult beetles are active, they may disperse and cause further damage, so it is important to avoid overly disturbing these trees. Marked, infested trees will be removed and burned during the late fall and winter. Because the available control method is so disruptive, USDA–APHIS and WI DATCP are encouraging early detection by informing citizens of what to look for.

An adult ALB is 1-1.5 inches long, and has conspicuous white spots on its glossy black back. Its antennae are slightly longer than its body and are black and white striped. The female makes ½ inch oval egg-laying niches in the bark. Inside, the larvae hatch from the eggs and bore into the wood for several months, which causes sawdust to accumulate on branches and on the ground around infested trees. Adults emerge through circular exit holes that can be up to 3/8 inch in diameter.

Other common Wisconsin insects that may resemble ALB are the white spotted sawyer (usually smaller than one inch in body length), European sawyer (rusty, rather than a glossy appearance on its back), and cottonwood borer (more white areas on its back). If you see a beetle that resembles this description, have the beetle identified and evaluated by a DNR forester or forest pest specialist, or contact USDA–APHIS or WI DATCP.

The following web sites contain more information, including photos, on ALB:

http://www.aphis.usda.gov/ppq/longhorn
http://dnr.state.il.us/ildnr/offices/pubaffrs/asian.htm

## Scorch Symptoms on Red and Sugar Maple - unknown or combination of factors

Samples of sugar maple foliage with the following symptoms were received from Shawano County in northcentral Wisconsin in July: green leaves with brown or chlorotic edges; discoloration sometimes covering the entire leaf margin, sometimes only portions of the margin. These symptoms are referred to as "scorch," which can be caused by a number of factors. Two factors which may have contributed to scorch in 1998 were hot dry weather in late spring and early summer, and infection by a group of fungi known as Anthracnose. It is unknown which factor played a more significant role. In some cases, scorch symptoms covered the whole crown. Affected trees could show symptoms of dieback in 1999, responding to the stress of scorch and lack of moisture during the 1998 growing season.

## Mortality and Top Dieback of Red and Jack Pine - drought stress/Sphaeropsis shoot blight and canker

Natural and planted jack and red pine regeneration in Eau Claire and Jackson counties suffered mortality and top dieback in June of 1998. Symptoms were common and widespread in areas where weed control was not pursued. Affected trees were infected with the fungus *Sphaeropsis sapinea.* This fungus is known to invade and progress in tissue that is under drought stress. The lack of moisture during the growing season and competition for moisture from weeds, combined to create a high-risk situation for red and jack pine regeneration. The sites were also very sandy and nutrient-poor. Disease incidence was up to 50% on some sites. Similar sites, where weed control had been pursued, showed a very low rate of infection.

## Necrosis of Needle Tips of Balsam Fir Christmas Trees - winter dessication

Browning of the needle tips of balsam fir Christmas trees was common and widespread in Wisconsin during 1998. The mild weather during February, is likely the factor that caused this symptom. If warm weather, accompanied by warm winds, occurs during the winter, conifers are likely to loose moisture from their stomata. The frozen ground prevents the trees from replacing the moisture and desiccation of the foliage occurs. Needles that turned completely brown, defoliated during the growing season.

## White and Bur Oak Leaf Curl and Deformation - unknown

Bizarre and uncommon symptoms occurred on white and bur oak in southern Wisconsin in 1998. Affected trees had curled, subnormal sized leaves; leaves were often chlorotic. The impact of this problem will vary, depending on the health of affected trees. Trees already in decline are likely to accelerate towards death; healthy trees with full crowns are likely to survive with minimal impact on growth. In 1999, forest pest specialists will attempt to determine which factors are involved.

## Dieback of Terminal Shoots of Fraser Fir Christmas Trees - frost damage

In 1996, '97 and '98, top dieback of Fraser fir Christmas trees in central and northern Wisconsin and the lower peninsula of Michigan was observed. Symptoms included necrosis of developing terminal and lateral shoots near the top of the tree. Affected shoots eventually turned brown, curled and died. Isolations to locate a disease organism only revealed the presence of secondary fungi. After two years of observations and isolations, we concluded that spring frost, killing succulent developing shoots, must be the primary cause of injury. Within a tree and between trees, shoots of Fraser fir develop at different times; susceptible tissue appears to be present when the shoots are approximately ½ elongated. Shearing affected shoots can help reshape the tree somewhat, but repeated injury can severely deform trees.

## Annosum Root Rot - *Heterobasidion annosum*

This root rot-causing fungus was first observed in Wisconsin in 1993. Two known sites (Adams County and Iowa County) continue to be the only two sites where the presence of this pathogen has been confirmed. A new pocket of dying trees was observed at the Iowa County site. Infected species included red oak, and white and red pine. Efforts to severely reduce inoculum at the Iowa County site are planned for the fall of 1999. Infected stumps and roots will be dug up and either burned or otherwise destroyed.

## RECENT PUBLICATIONS

(To order: tear out this page, mark those publications you would like and send to: Jane Cummings Carlson, DNR Forest Health Protection, 3911 Fish Hatchery Road, Madison, WI 53711, FAX (608) 275-3236, or Email: cummij@dnr.state.wi.us)

_____ ***Asian Long-horned Beetle: Be on the lookout for this new tree-killer.*** 1998. Wisconsin Department of Agriculture, Trade and Consumer Protection, Plant Industry Bureau, ARMPUB76.

_____ [1] ***Herbicides for forest management 1998.*** Hall, D. and J. Martin. 1998. University of WI Extension, Forestry Facts No. 76, 7 pp.

_____ ***Insects and Pathogens Affecting Forests on the Northern Highland American Legion State Forest: A summary of historical data and a look to the future.*** Guthmiller, M., Cummings-Carlson, J., Seiger, S., and Kevin,E. 1998. Wisconsin Department of Natural Resources, Forest Health Protection, Bureau of Forestry.

[1] Updated annually.

# THE RESOURCE

(1996 Forest Inventory Data)

## Proportion of Forest Land and Timberland

The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16.0 million acres, representing 46 percent of the total land area. The state now has the most forestland it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84 percent of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state is maple-basswood, which makes up 5.3 million acres (34%) of Wisconsin's timberland area. Conifer types represent 16 percent of the total timberland area (pine forests - 8%, spruce-fir - 6%, and swamp conifers - 2%).

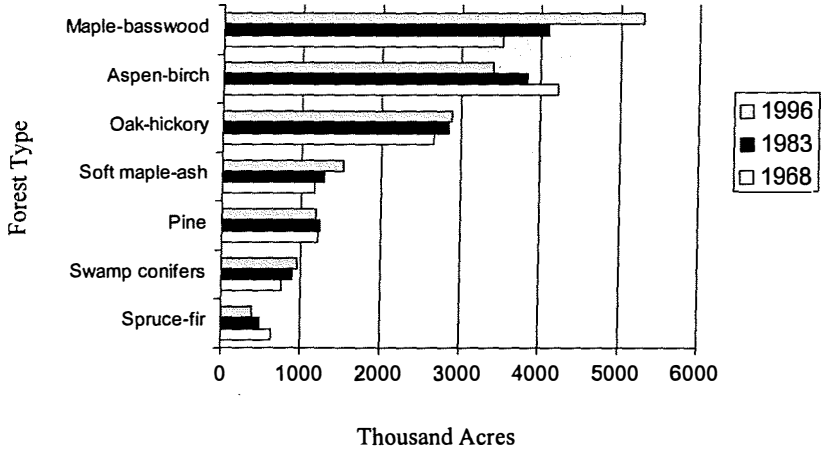



Figure 2. Area of timberland (in thousand acres) by forest type for 1983 and 1996. Data taken from 1996 FIA survey.

Wisconsin timberland increased by 940,000 acres between 1983 and 1996.

- 1968 - 14.54 million acres
- 1983 - 14.76 million acres
- 1996 - 15.70 million acres

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

## Ownership of Wisconsin's Timberland

Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57 percent of all timberland in 1996 (Figure 3). Counties and municipalities are the largest group of public owners, holding 15 percent of the total area of timberland in Wisconsin. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

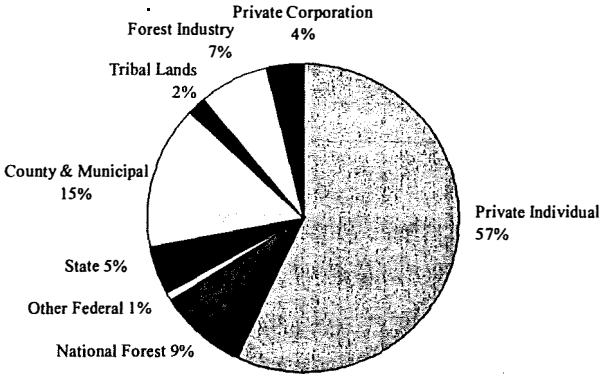



Figure 3. Ownership of Wisconsin's forests. Data taken from 1996 FIA survey.

## Growing-stock Volume of Wisconsin's Timberland

Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in 1996 (Figure 4), reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for ¾ of all growing-stock volume. The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple. The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

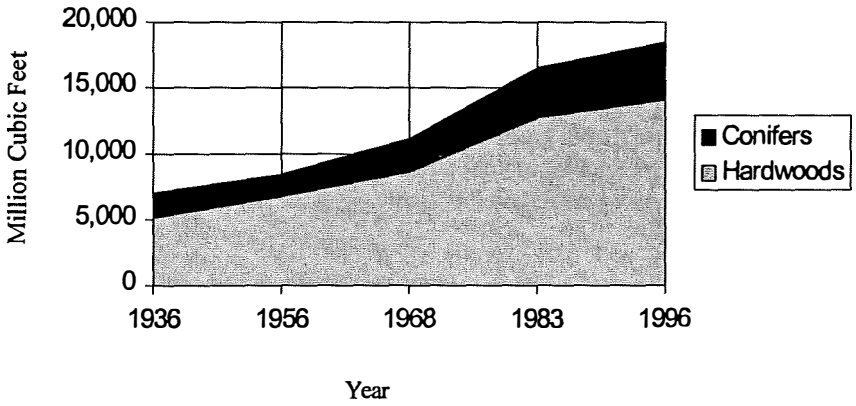



Figure 4. Growing stock volume (in million cubic feet) on timberland in Wisconsin, 1936-1996. Data taken from 1996 FIA survey.

## Most Common Species Groups of Wisconsin's Timberland

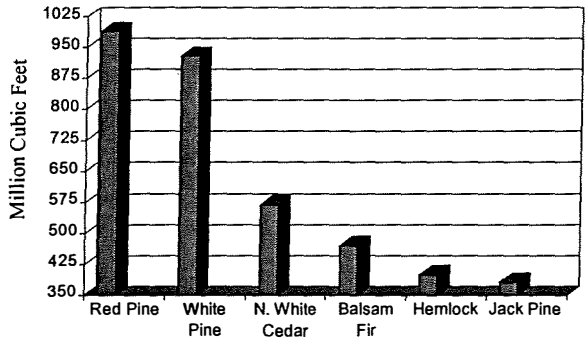



Figure 5. Most common conifer species (in million cubic feet)on timberland in Wisconsin. Data taken from 1996 FIA survey.

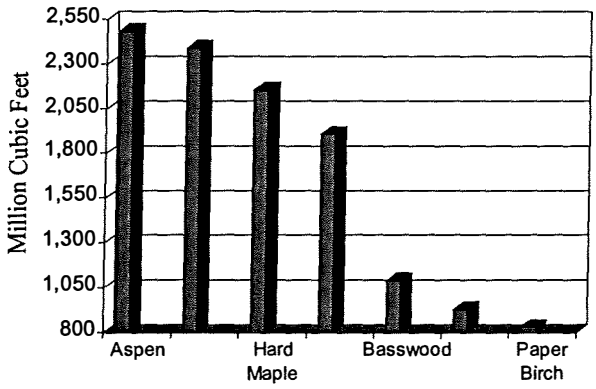



Figure 6. Most common hardwood species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

# MAJOR PESTS OF 1998

## Introduced basswood thrips

The basswood resource of northwest Wisconsin was only lightly affected by introduced basswood thrips in 1998. We had less than 15,000 acres of IBT defoliation, which occurred as small spots scattered over five counties (Figures 7-11). Total acreage of defoliation by county were as follows: Bayfield – 2,027, Polk – 636, Rusk – 6,204, Sawyer – 1,007, and Washburn – 3,571.

Most of the defoliation was no worse than moderate, with pockets of heavy defoliation present only in Rusk County. Despite a fairly dry early summer, most trees appeared to recover well by later in the growing season. No significant dieback or mortality was observed in any basswood stands.

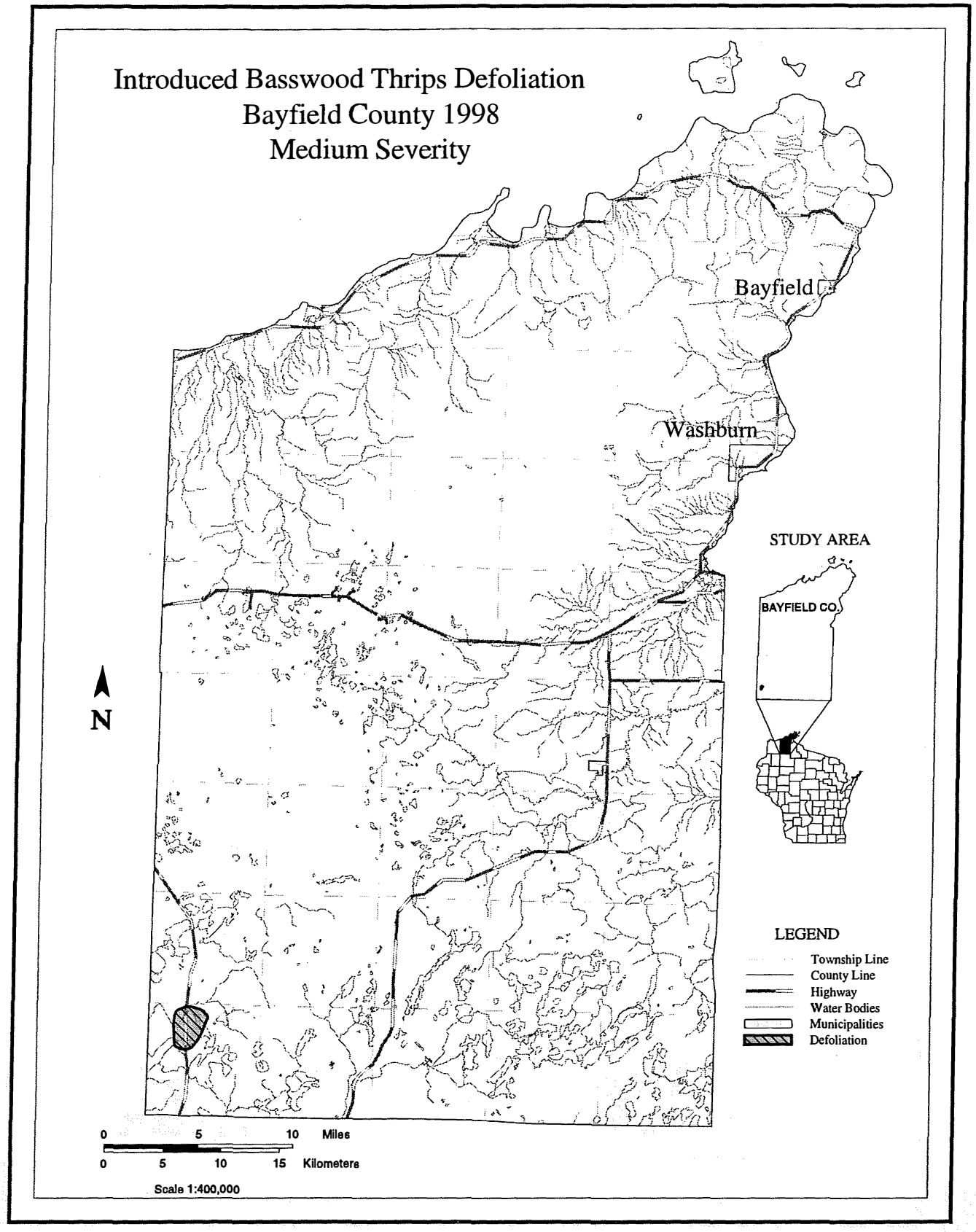



Figure 7. Area of basswood defoliated by introduced basswood thrips, Bayfield County 1998.

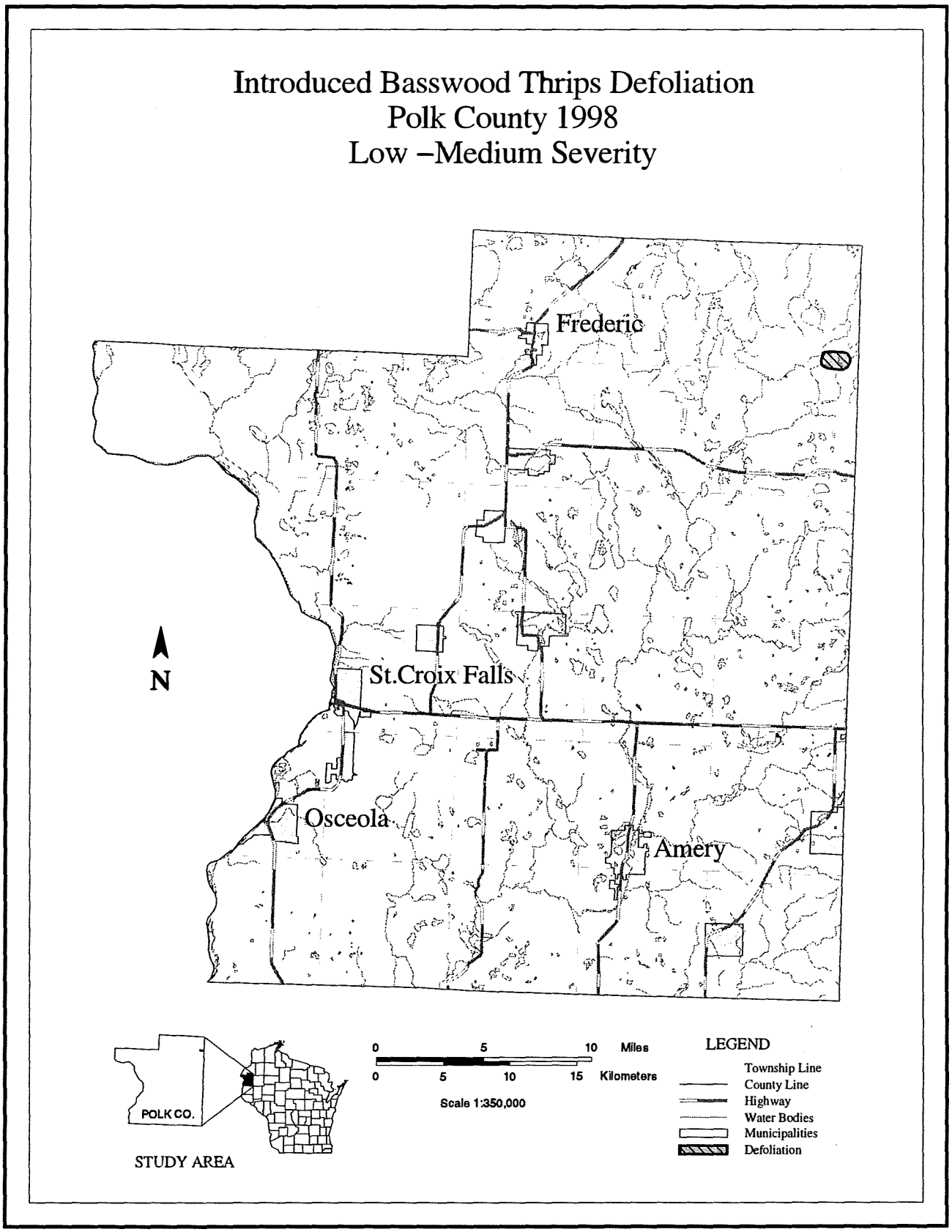



Figure 8. Area of basswood defoliated by introduced basswood thrips, Polk County 1998.

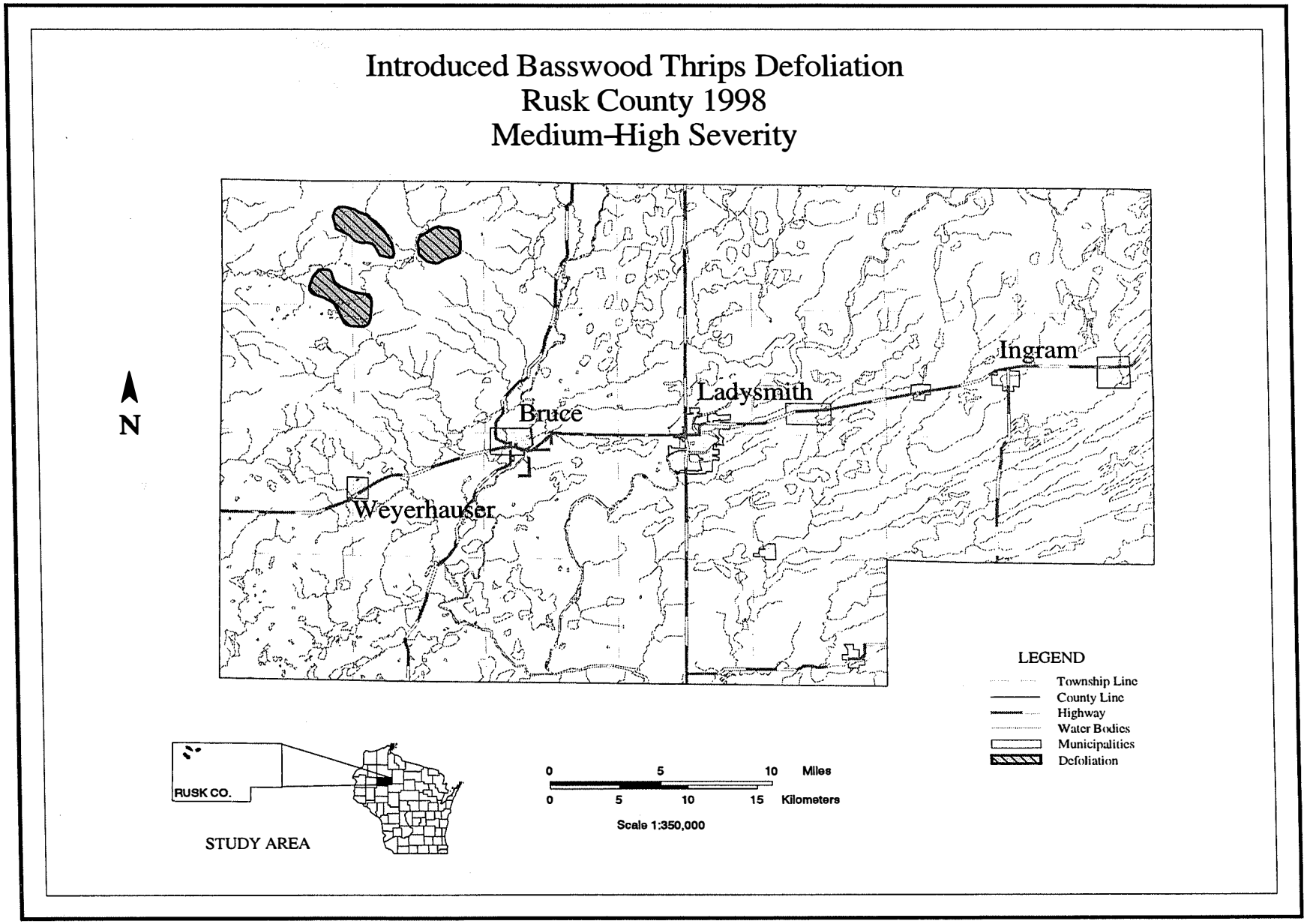



Figure 9. Area of basswood defoliated by introduced basswood thrips, Rusk County 1998.

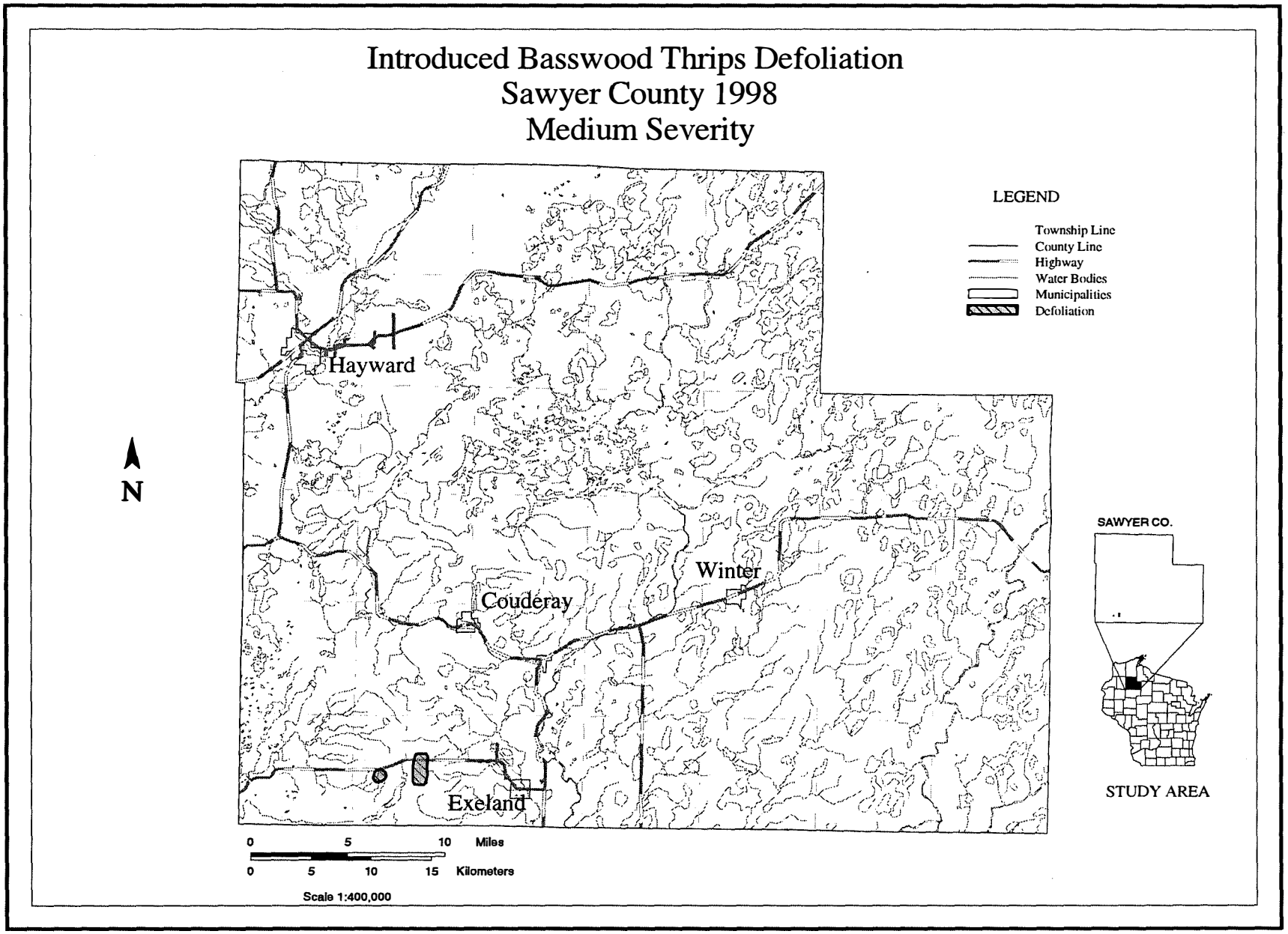



Figure 10. Area of basswood defoliated by introduced basswood thrips, Sawyer County 1998.

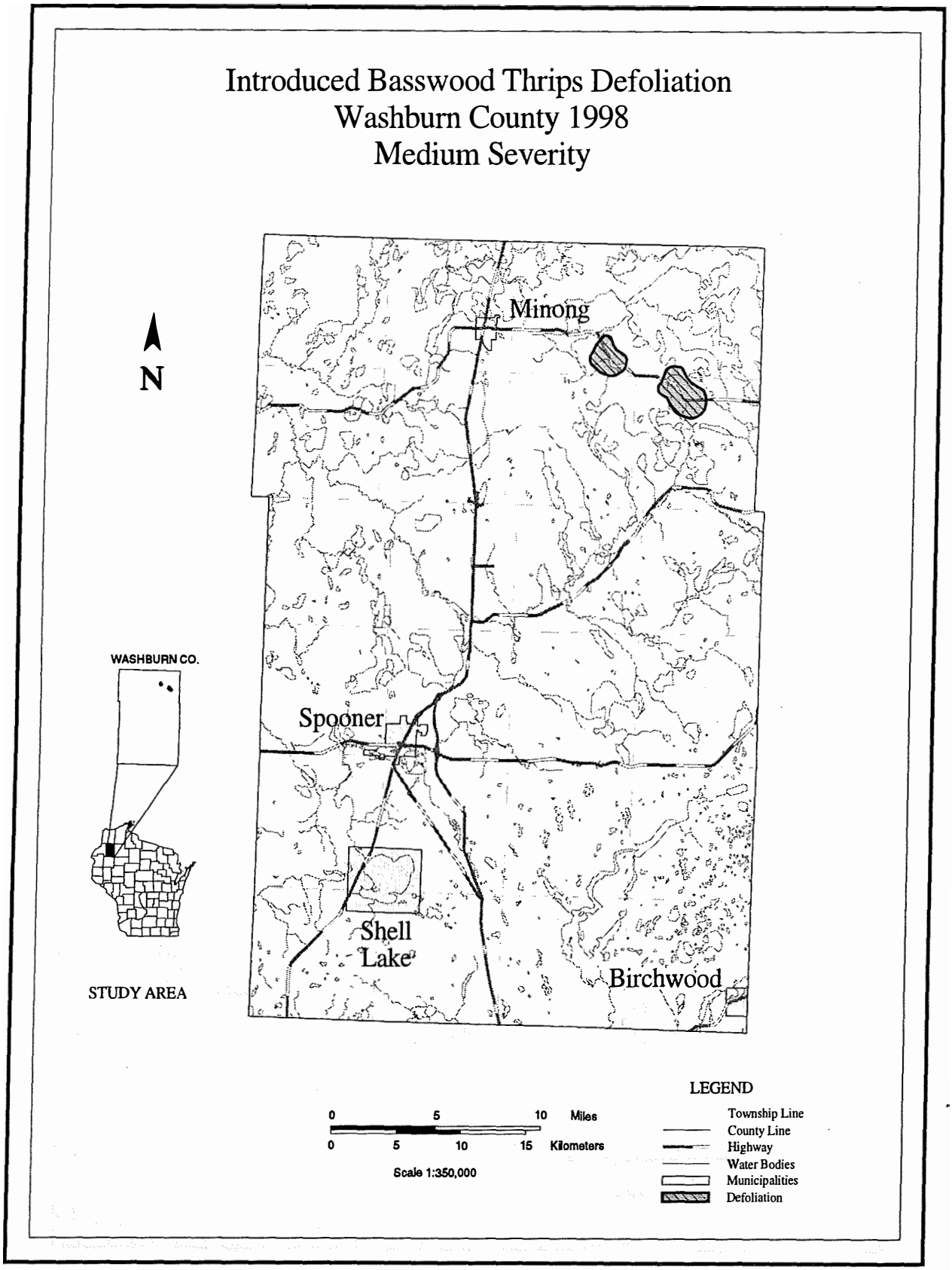



Figure 11. Area of basswood defoliated by introduced basswood thrips, Washburn county 1998.

## Jack pine budworm

Jack pine budworm defoliated areas in Adams and Juneau counties totaling 2,289 acres (Figures 12-13). The affected areas suffered moderate to heavy defoliation. Understory jack and white pines were heavily defoliated, and some will not survive. Based on egg mass counts, these areas could experience heavy defoliation again in 1999.

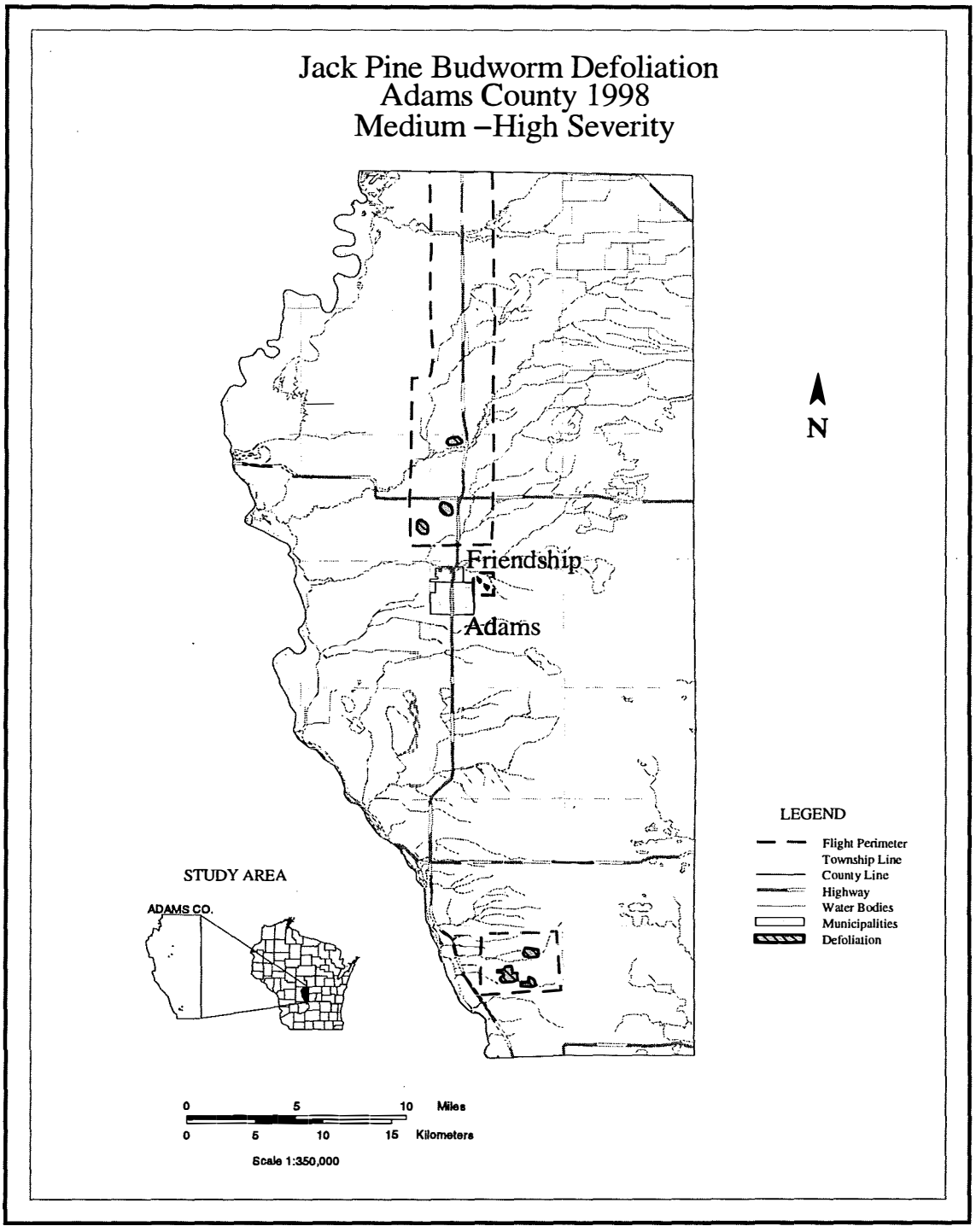



Figure 12. Area of jack pine defoliated by jack pine budworm, Adams County 1998.

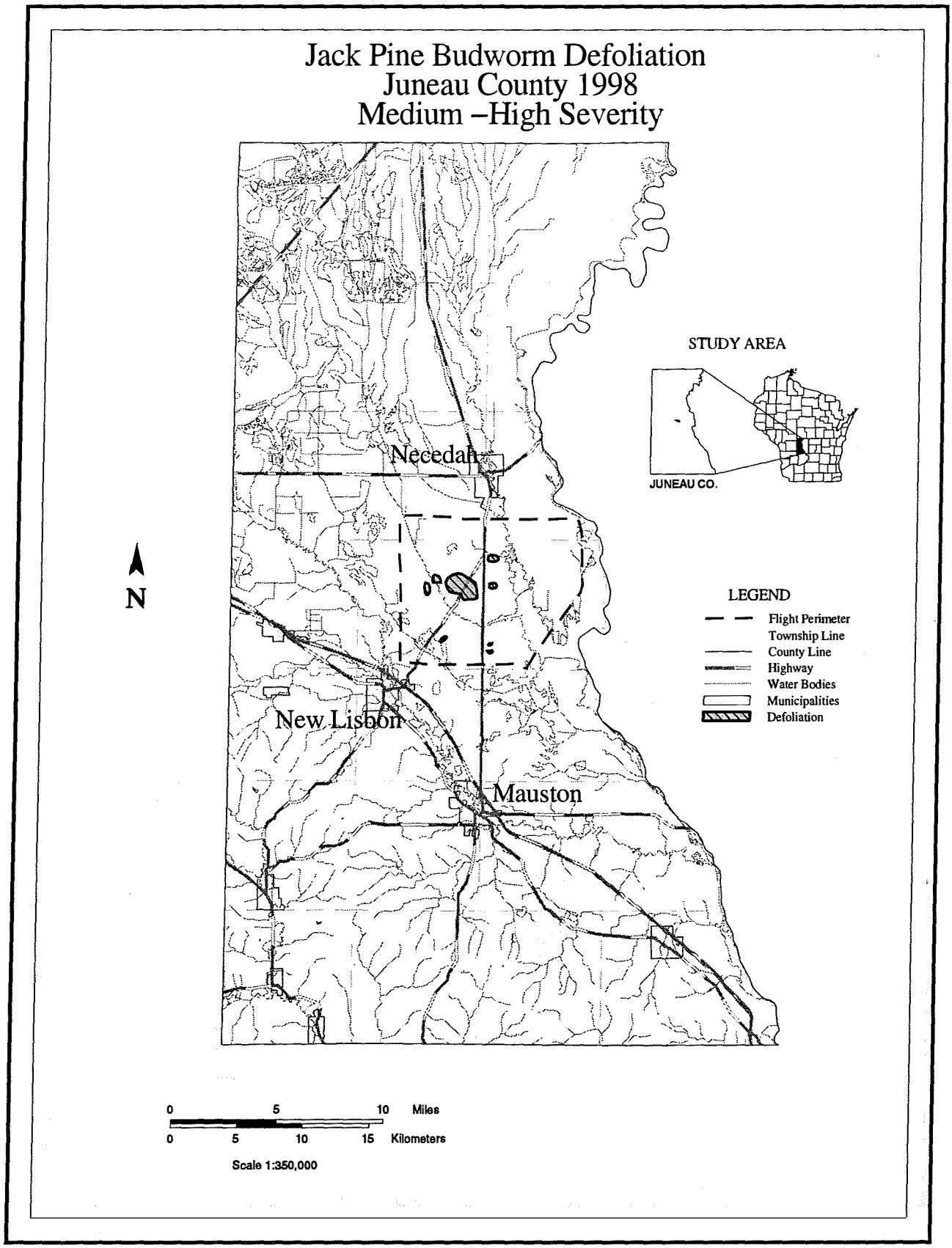



Figure 13. Area of jack pine defoliated by jack pine budworm, Juneau County 1998.

## Large aspen tortrix

The large aspen tortrix caused moderate to heavy defoliation on 21,330 acres of aspen in Oneida County (Figure14). Feeding damage became noticeable in early May, and was complete by early June. Defoliation was near 100 percent in several pockets. Damage by this pest was also found in the Nicolet National Forest in Florence County.

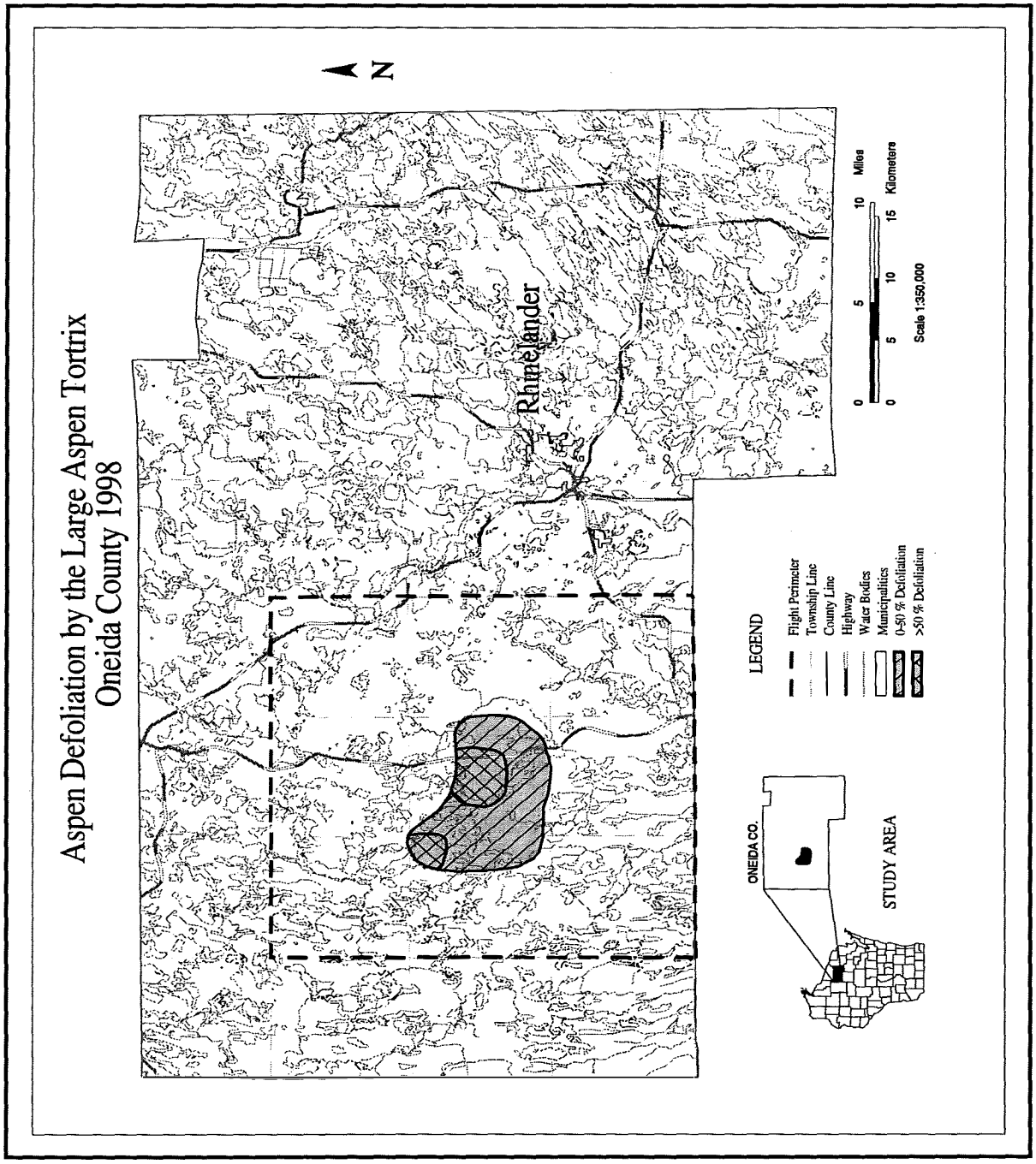



Figure 14. Area of aspen defoliated by large aspen tortrix, Oneida County 1998.

## Lesser maple spanworm

The lesser maple spanworm, *Itame pustularia,* occurs in the eastern United States and Canada. It defoliates red maple in the late spring. This inchworm is native to Wisconsin but has not been reported causing noticeable defoliation before 1998.

Full grown larvae are about ¾ inch long, slender and light green with narrow yellow and white longitudinal stripes. When the larvae finish feeding they change to a pink color, web down to the ground, and dig into the litter layer where they pupate. They tend to web down en masse which is very inconvenient for people recreating in outbreak areas.

The adult moths are about an inch wide, fragile and white with four, equally spaced dark-brown spots on the front edge of each front wing. Extending from each dot is a faint orange-brown line. These lines often disappear as the moths age and loose their wing scales. In outbreak areas, clouds of white moths rise up from the ground layer when disturbed during the daytime. The adults are normally present from mid July to September. The females lay eggs singly on tree bark, on lichen growing on trees, or in the litter where they overwinter.

The larval feeding period occurs from mid May through July in normal years. Larvae eat holes in leaves, giving them a very tattered appearance. In very heavy defoliation, only the leaf veins remain uneaten. Defoliation by lesser maple spanworm occurs several weeks later than fall cankeworm defoliation; cankerworm defoliation ended in mid May this year, spanworm defoliation ended about June 10.

Approximately 9,835 acres of red maple in Sauk County were defoliated by the lesser maple spanworm this year (Figure15). Understory saplings were often completely defoliated, while mature trees were only lightly to heavily defoliated. The defoliation pattern was spotty; individual trees heavily defoliated and adjacent trees nearly untouched. Pockets of heavily defoliated trees often occurred near the center of the outbreak area between Plain and Natural Bridge State Park.

Because there had been plenty of rain in 1998, the defoliated trees produced new leaves and recovered. In a dry year, many of them probably would have begun to decline or die.

The population level for next year is not predictable; we have no outbreak history in Wisconsin to refer to. The abundance of parasitized and diseased larvae observed in the population hints at a probable collapse of the outbreak.

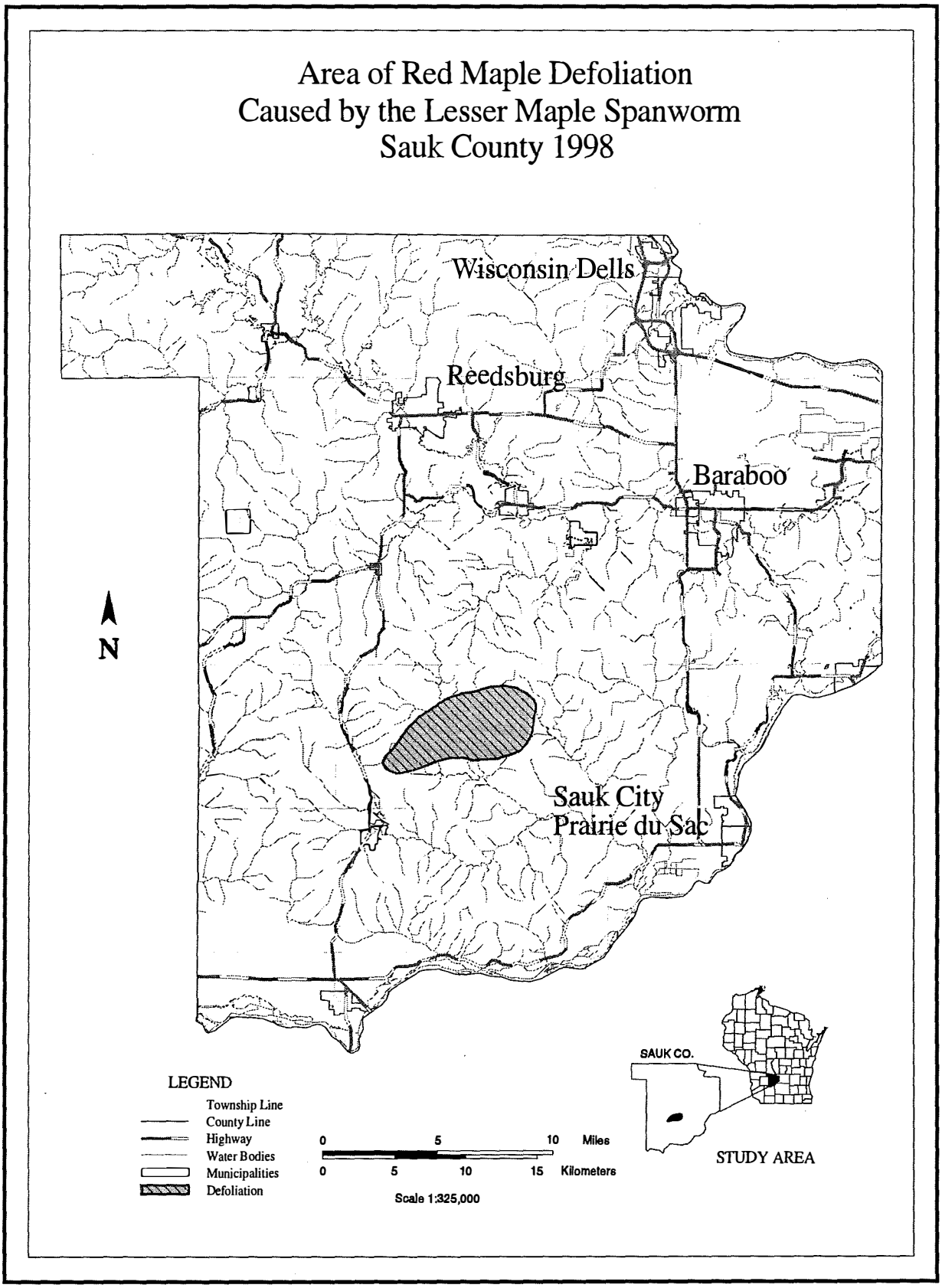
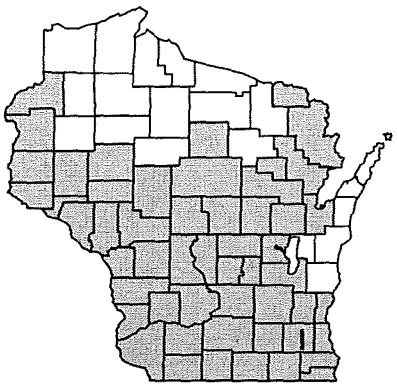



Figure 15. Area of red maple defoliated by lesser maple spanworm, Sauk County 1998.

## Oak wilt

This disease continues to move, primarily through root-graft spread, throughout the southern 2/3 of the state. A committee, chaired by Dr. Robert Miller, UW-Stevens Point, has developed a model ordinance for management of oak wilt in communities. This ordinance appears in Appendix A.



County distribution of oak wilt plus Florence and Lincoln counties: all counties where oak wilt management guidelines apply.

Survey efforts continued to be focused on determining the effectiveness of pruning and cutting guidelines developed for Wisconsin's electric utilities; 1998 was the fourth year of this survey. Results indicate that, in most areas surveyed in 1995-'98, overland spread of oak wilt has not occurred via pruning of oak by Alliant (formerly Wisconsin Power & Light) in southwestern and south central Wisconsin. However, in two locations, results were inconclusive and present some potential concerns regarding the current guidelines. 1999 will be the last year of this survey, at which time, a full report will be available.

The leading edge of oak wilt in Marathon County did not advanced in 1998 (Figure 16). Oak wilt has stabilized around the Mosinee area and south along the Wisconsin River. The majority of oak wilt in these areas is associated with construction damage.

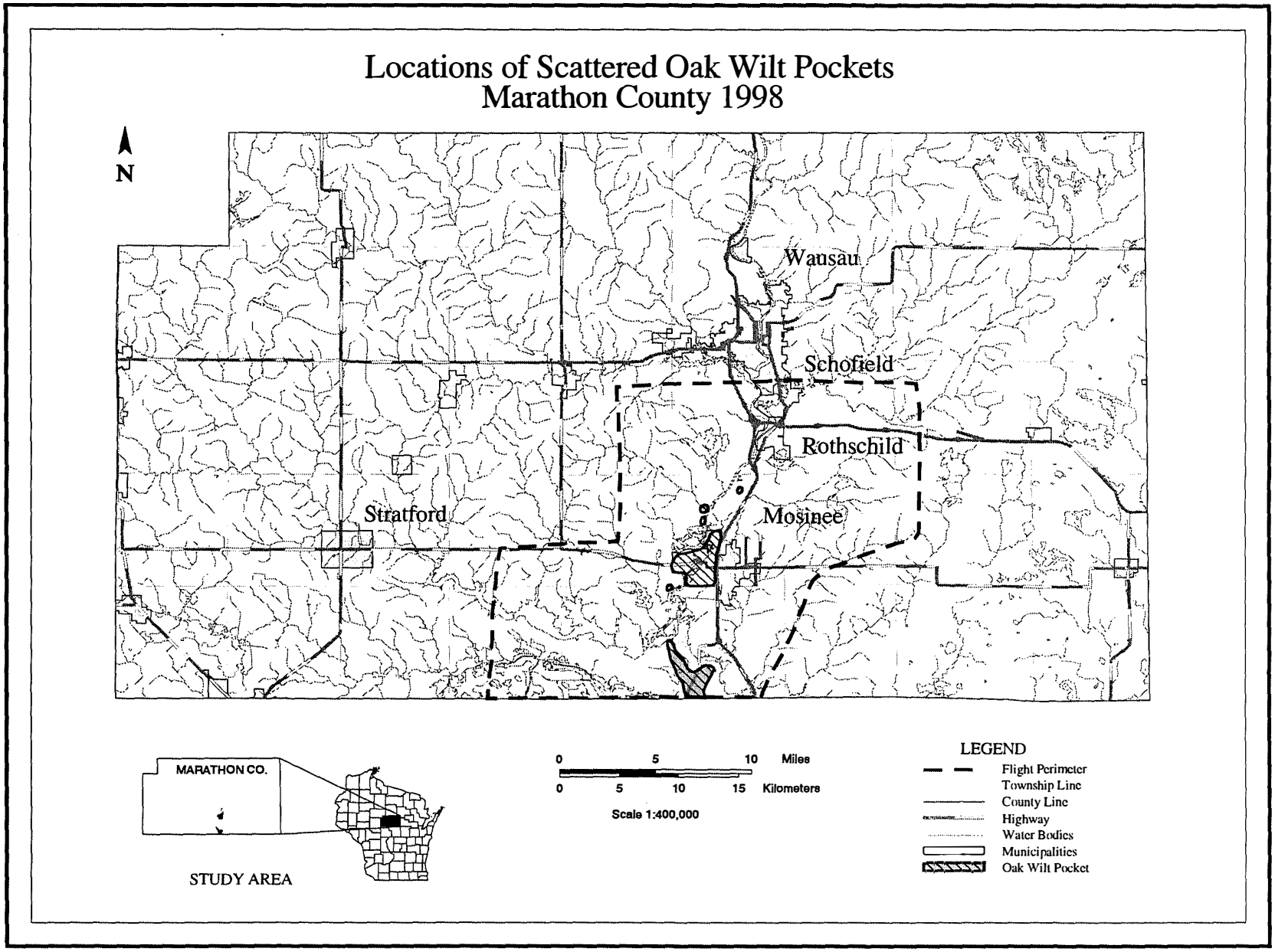



Figure 16. Locations of oak wilt pockets, Marathon County 1998.

## Storm damage

On May 31, a widespread downburst wind event termed "derecho" occurred in southcentral and southeastern Wisconsin. Hurricane-force straight-line winds with gusts of 100 to 128 miles per hour ripped through 12 counties. In Sauk and Dane counties, an estimated 29,000 acres were damaged by the severe weather (Figure 17). Two areas, one approximately 2-3 miles wide and 20 miles long, had scattered patches of downed trees; oak and pine were the species most commonly affected. Oaks were either topped, branches ripped off or split open. Pines were primarily broken about 10 feet off the ground. This area included a lot of scattered small woodlots mixed with agricultural land. Damage in and around the cities of Lodi and Sauk was evident. In Sauk City, a four-acre oak-grove city park was all but destroyed. Bur, white and red oaks were uprooted and ripped apart.

Another area, just west of Devils Lake State Park, incurred terrific damage to trees. It included a piece approximately 100-200 feet wide and six miles long. The trees in this swath were leveled.

Mirror Lake State Park was also impacted severely by the storm. The high winds moved from west to east through the park. The pattern of damage indicated the winds were highest at high points on the edge of the lake and in areas where the winds were funneled through a valley or dip in the topography.

Damage to trees at Mirror Lake State Park, in order of frequency, included 1) uprooting, 2) broken branches, 3) torn crown sections originating at weak unions and 4) stem breakage. Species most commonly affected included black, red, white and bur oaks, red and sugar maple, black cherry, trembling aspen and jack pine. Whether or not a tree fails through uprooting is determined by the following factors: 1) wind speed 2) root development, 3) soil type, 4) crown mass and 5) soil moisture content. Each of these factors set many of the trees up to failure. The wind speeds were in excess of 100 mph; root development was primarily lateral, not vertical; the soil in the park has a very high sand component with low cohesion strength; the crown masses were large and provided resistance to the high winds; and the soil moisture was high, reducing the shear strength of the sand. Soil moisture drains very slowly at Mirror Lake State Park due to a layer of sandstone that impedes drainage.

All of these factors contributed to the uprooting, and the manner in which the trees uprooted (whole root plates lifted as opposed to roots breaking) fit a condition described as "soil failure." Initially, approximately 200 trees were noted as suffering severe damage. In the week to 10 days following the storm, trees that had no outward signs of being damaged, started tipping over or loosing portions of their crowns. Further evaluation showed trees with the following characteristics were failing: 1) had large crowns 2) were located in areas of the park that suffered the most damage from the May 31 storm and 3) were located in areas of the park where soil moisture was highest. The roots of failing trees had been loosened during the storm and were not able to hold the weight of heavy crowns as the shear strength of the soil was reduced each time it rained. Trees that fit the profile of being susceptible to failure, based on the above factors, were marked for removal.

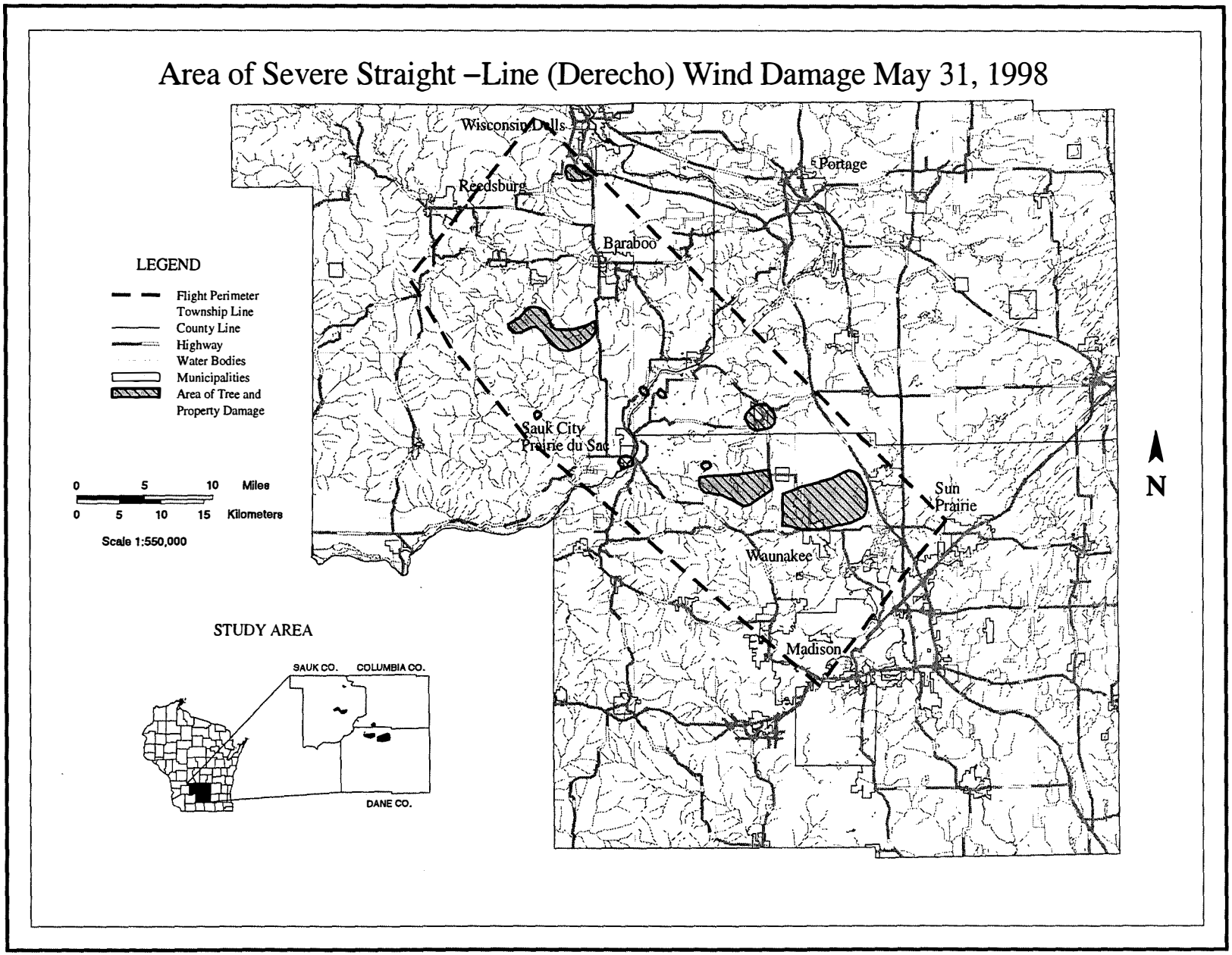



Figure 17. Area of severe straight-line wind damage; Dane, Columbia, and Sauk counties, May 31, 1998

Likewise, on June 27, severe straight-line winds ripped through Buffalo, Jackson, Monroe, and Trempealeau counties, literally creating thousands of acres of horizontal timber. For landowners and foresters alike the aftermath created a sense of shock. The overwhelming devastation left them wondering, "Now what?"

An aerial assessment of the damage determined that approximately 271,000 acres of forested land was damaged, covering a ten-mile wide swathe from southern Buffalo County to Fort McCoy in Monroe County (Figure 18). A separate storm ripped a path through northern Vernon County into southwest Monroe. Years of management and labors of love were lost. Over 3,000 acres of previously thinned red pine plantations were snapped off, flattened or bent. Oaks and other hardwoods were tipped or broken off. Within days, loggers began moving into the area and making contacts with landowners to purchase the damaged timber.

Over 200 people who were searching for information and assistance attended an informational meeting in July. Local foresters handled many calls and numerous field visits to provide recommendations. Salvage sales were set up on the 3,000 DNR acres affected, as well as on many private lands, with active forestry consultant involvement.

Fortunately, the storm did have some positive effects. Loggers came into new areas and became aware of the available softwood resource. Some undamaged pine plantations were thinned that would not have been otherwise. The storm also provided natural thinnings in younger oak stands.

Many cleanups have been completed and where possible, merchantable hardwood and softwood was salvaged. Some of the hardwood, however, is too broken up and too inaccessible to be salvaged. Some mechanical site prep has been accomplished with many planting plans set up for spring 1999. With such a massive area affected, however, natural reproduction is the most likely source of the next forest.

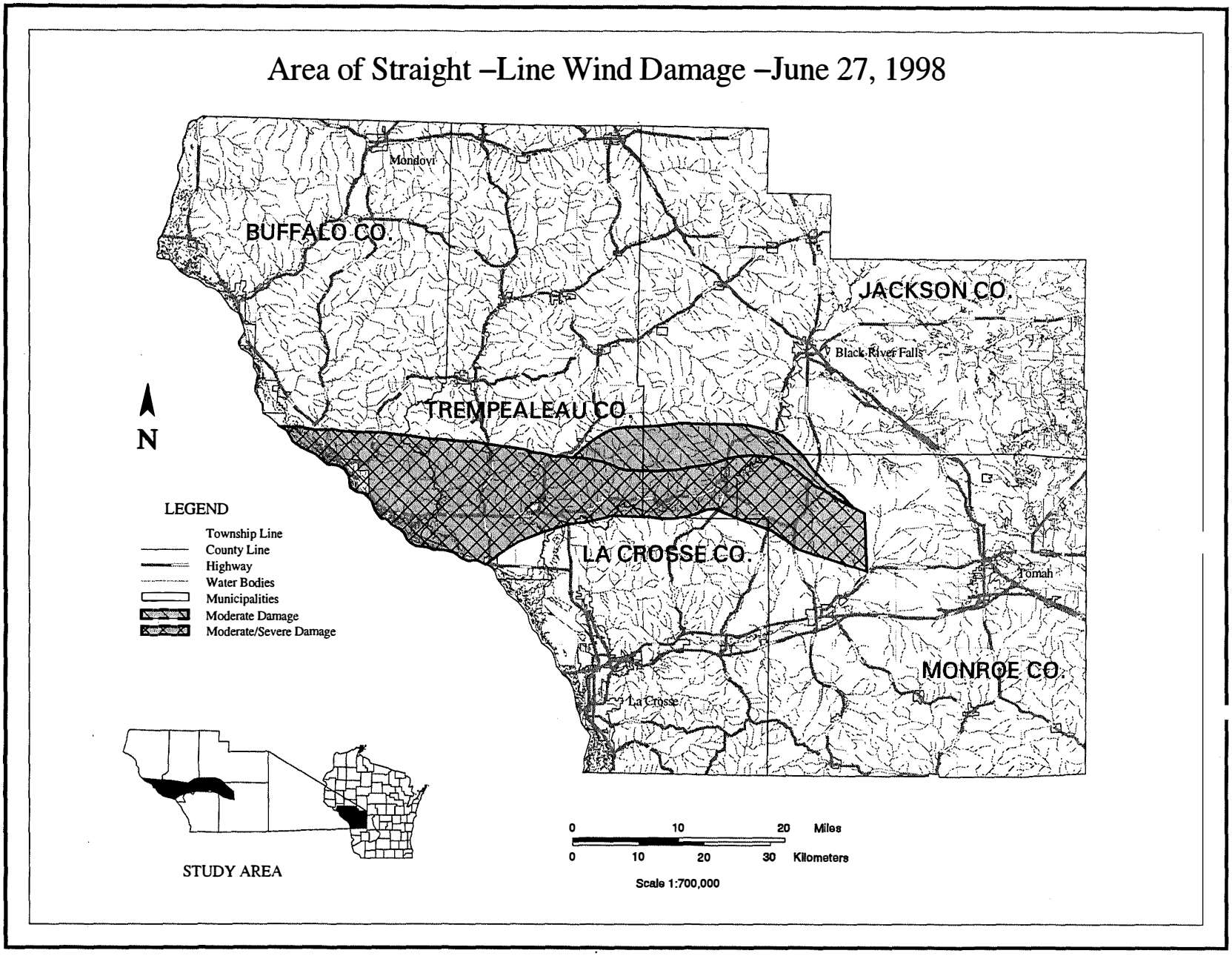



Figure 18. Area of straight-line wind damage: Buffalo, Jackson, Monroe, and Trempealeau counties, June 27, 1998

## Gypsy Moth

The big news this spring for foresters with respect to the gypsy moth was the expansion of the quarantine zone in Wisconsin. Thirteen more counties on the eastern side of the state were added in June to the four in the Door Peninsula placed under regulation last year. Quarantine regulations require forest products, Christmas trees and nursery plants be inspected prior to shipment out of the quarantined area to insure gypsy moth is not transported along with the load.

The spray program went smoothly this spring with 61 sites treated for a total of 34, 711acres. The bacterial insecticide Btk was applied two times, one week apart, to all sites in mid May. The majority of the acreage sprayed was in the center of Wisconsin, in the counties of Portage, Wood and Waushara.

In late June, two more sites were treated to slow the spread of the gypsy moth. Instead of Btk, however, flakes containing the scent (pheromone) of the female moth were distributed by plane over parts of Devil's Lake State Park and the Southern Unit of the Kettle Moraine. By saturating the environment with the female moth's pheromone, we interfere with the ability of the male to find the female and her eggs go unfertilized. The advantage of pheromone flakes is that it has no effect on other species. Unfortunately, it is expensive and is only possible were gypsy moth populations are low and isolated. We are using it to reduce and possibly eliminate gypsy moth at these sites because of concerns for rare species that could be effected by Btk.

Biological control efforts in WI are based on three ideas: selecting introduction sites that are favorable for establishment of the biological control, use of natural enemies that are specific to the gypsy moth, and post-release surveys to verify establishment and fine-tune our site selection.
In 1998 we continue to work with the three species selected on the basis of their specificity, and their proven ability to establish in very sparse host populations and survive in our climate. *Entomophaga maimaiga*, the fungal disease that has decimated gypsy moth in the northeastern states, was introduced into 22 sites in 1997 and will be released at 27 more this year. We use ground gypsy moth caterpillars that died of this fungal disease as our innoculant. The high concentration of spores in this material may contribute to our unusually high rate of establishment of 50%. We released the egg parasitoid *Ooencyrtus kuvanae* at six sites and found it had also considerably extended its range from where we had originally found it at the base of the Door Peninsula in 1995. This stingless wasp is tiny, smaller than a gnat and poses no threat to people. *Cotesia melanoscela*, another tiny wasp, parasitizes gypsy moth larvae and was released at three sites in 1997. Unfortunately, we did not recover this species in 1998.

This summer, 108,704 gypsy moth males were caught in pheromone traps this summer, up from 95,039 in 1997. Alternate life stages were found at 129 sites and while this is down from 211 sites discovered last year, the density of egg masses at several sites is much higher than we have seen in the past. The population of gypsy moth has decreased north of Rt. 29, possibly as a result of late frosts in this area. The population in the central sand counties of Waushara, Waupaca and Portage continues to grow as does the one in Madison and the colonies in the Wisconsin River valley. Establishment of this pest along the river is particularly disturbing as the continuous woodland along the Wisconsin and into the Mississippi will allow unimpeded natural spread of gypsy moth into the other states of the Midwest.

# SUMMARY OF OTHER PESTS REPORTED IN 1998

| Pest | Host | Damage | Location |
|---|---|---|---|
| **ASH** | | | |
| Ash plant bug *(Tropidosteptes amoenus)* | Ash | Light to heavy feeding damage - heavy damage on already stressed trees. | Marathon County |
| Ash plant bug *(Tropidosteptes amoenus)* | Ash | Moderate to heavy feeding damage with some premature leaf fall. | Sawyer, Washburn counties |
| Mountain ash sawfly *(Pristiphora geniculata)* | European mountain ash | Widespread, light to moderate defoliation. | Burnett, Washburn counties |
| **ASPEN** | | | |
| Aspen blotch miner *(Phyllonorycter spp.)* | Aspen | Moderate to severe mining damage on roadside trees. | Langlade, Lincoln, Oneida counties |
| Large aspen tortrix *(Choristoneura conflictana)* | Aspen | Small pockets of moderate (<70%) defoliation. | Bayfield County |
| Large aspen tortrix *(Choristoneura conflictana)* | Aspen | Moderate to severe defoliation. | Oneida County |
| **BASSWOOD** | | | |
| Introduced basswood thrips *(Thrips calcaratus)* | Basswood | Light to severe defoliation. | Florence, Forest, Langlade, Lincoln, Oneida counties |
| Obliquebanded leaf roller *(Choristoneura roseaceana)* | Basswood | Heavy defoliation. | Marinette County |
| **BIRCH** | | | |
| Birch leafminer *(Fenusa pusilla)* | Paper birch | Widespread, light to moderate defoliation on edge birch. | Sawyer, Washburn counties |
| **BOXELDER** | | | |
| Fall cankerworm *(Alsophila pometaria)* | Boxelder | Light to heavy defoliation. | Brown, Dane, Dodge, Portage, Richland counties |
| **BUTTERNUT** | | | |
| Butternut canker *(Sirococcus clavigignenti-juglanda cearum)* | Butternut | Decline and dieback. | Marathon County |
| **CHERRY** | | | |
| Eastern tent caterpillar *(Malacosoma americanum)* | Cherry | Webbing and defoliation. | Scattered throughout West Central Region |

## CHRISTMAS TREES

| | | | |
|---|---|---|---|
| Aphids *(Cinara spp)* | Scotch pine, white pine, and white spruce | Feeding on branches and main stem of trees. | Chippewa, Wood counties |
| Cyclaneusma needlecast *(Cyclaneusma minus)* | Scotch pine | Needle loss. | Dunn, Wood counties |
| Eastern gall rust *(Cronartium quercuum)* | Scotch pine | Galls on branches and main stem causing mortality. | Dunn, Wood counties |
| Eastern pine shoot borer *(Eucosma gloriola)* | Scotch pine | Lateral shoots and branches twisted and distorted. Branches broke off easily where they were damaged. | Wood County |
| Eastern spruce gall adelgid *(Adelges abietis)* | White spruce | Pineapple shaped galls on shoots. | Chippewa, Eau Claire counties |
| Lirula needlecast *(Lirula macrospora)* | Spruce | Severe needle discoloration and cast. | Lincoln County |
| Lirula needlecast *(Lirula mirabilis, Lirula nervata)* | Balsam fir | Moderate needle discoloration and cast. | Forest, Langlade counties |
| Lophodermium needlecast *(Lophodermium seditiosum)* | Scotch pine | Needle loss. | Dunn, Wood counties |
| Pine bark adelgid *(Pineus strobi)* | White pine | Small numbers found on main stem. | Adams County |
| Pine pitch midge *(Cecidomyia candidipes)* | White Pine | Found pitch blisters on branches and main stem with pinkish maggots present | Clark County |
| Pine root collar weevil *(Hylobius radicus)* | Scotch pine | Root collar area girdled, leading to decline/mortality. | Trempealeau County |
| Pine spittlebug *(Aphrophora cribrata)* | Scotch pine | Branch flagging. | Dunn, Wood counties |
| Pitch midge on white pine *(Cecidomyia candidipes)* | White pine | Presence of larvae in pitch masses on exported trees has caused concerns in importing states. | Collected in Clark County. |
| Rhizosphaera needlecast *(Rhizosphaera pini)* | Balsam fir | Moderate to severe needle discoloration and cast. | Langlade County |
| Sooty mold | White pine | Heavy sooty mold on branches and foliage. | Adams County |
| White pine weevil *(Pissodes strobi)* | White pine and white spruce | Terminal leaders killed. | Chippewa County |
| Zimmerman pine moth *(Dioryctria zimmermanni)* | Scotch pine and white pine | Branch mortality and damage to main stem. | Adams, Dunn counties |

## ELM

| | | | |
|---|---|---|---|
| Dutch elm disease *(Ophiostoma ulmi)* | American elm | Branch flagging. | Marathon County |
| Wooly elm aphid *(Eriosoma americanum)* | Elm | Heavy infestation in a localized urban area. | Oneida County (downtown Rhinelander) |

## LARCH

| | | | |
|---|---|---|---|
| Larch needlecast *(Mycosphaerella laricina)* | European larch | 60% incidence with 70% severity. | Burnett, Polk counties |

## MAPLE

| | | | |
|---|---|---|---|
| Bruce spanworm (*Operophtera bruceata*) | Sugar maple | Moderate to severe defoliation. | Florence, Forest counties |
| Greenstriped mapleworm *(Dryocampa rubicunda)* | Red maple | Less than 500 acres of heavy defoliation in one spot. | Washburn County |
| Lesser maple spanworm *(Itame pustularia)* | Sugar maple | Pockets of light defoliation. | Iron County |
| Logging wounds and/or sunscald | Red maple | Red maple saplings with wounds and callus material. Some dead trees with sapwood-rotting fungi fruiting on stems. | Clark County |
| Maple petiole borer (*Caulocampus acericaulis*) | Sugar maple | Light to moderate damage. | Florence, Oneida counties |
| Maple webworm *(Tetralopha asperatella)* | Sugar maple | Scattered defoliation. | Sawyer, Washburn counties |

## MISCELLANEOUS HARDWOODS

| | | | |
|---|---|---|---|
| Fall webworm *(Hyphantria cunia)* | Hardwoods | Light to moderate webbing and associated defoliation. Moderate to heavy webbing in portions of Buffalo and Pierce counties. | Scattered throughout West Central Region |
| Fall webworm (*Hyphrantria cunea*) | Hardwoods | Light to moderate webbing. | Oneida, Vilas counties |
| Fall webworm *(Hyphantria cunea)* | Hardwoods | Widespread, moderate to heavy defoliation. | Price, Rusk, Sawyer, Taylor counties |

## OAK

| | | | |
|---|---|---|---|
| Armillaria root rot *(Armillaria mellea)* | Black oak | Small diameter, suppressed trees dying. | St. Croix County |
| Kermes scale *(Kermes spp.)* | Northern pin oak | Widespread branch flagging. | Burnett, Douglas, Washburn counties. |
| Kermes scale *(Kermes spp.)* | Red oak | Shoot dieback. | Grant County |
| Oak lace bug *(Coryathuca arcuata)* | Burr oak | Scattered pockets of heavy bronzing. | Bayfield, Douglas, Washburn counties |
| Oak leaf tier (*Croecia semipurpurana*) | Red oak | Severe defoliation in small pockets. | Oneida County |
| Oak leaf tier *(Croecia semipurpurana)* | Oak | Light to moderate defoliation. | Florence County |
| Oak leaf tier *(Croecia semipurpurana)* | Red oak | Moderate to heavy defoliation in pockets. | Burnett, Washburn counties |
| Oak leaf tier/roller complex | Red and White Oak | Defoliation. | Marathon County |
| Oak twig girdler *(Oncideres cingulata)* | Northern pin oak | Widespread branch flagging. | Bayfield, Burnett, Douglas, Washburn counties |
| Oak webworm *(Archips fervidana)* | Northern pin oak | Approx. 10,000 acres of severe defoliation. | Washburn County |
| Oak wilt *(Ceratocystis fagacearum)* | Red and black oak | Tree mortality. | Throughout West Central Region |

| | | | |
|---|---|---|---|
| Oak wilt *(Ceratocystis fagacearum)* | Northern pin oak | Existing pockets spread, but no major advance. | Burnett, Polk counties |
| Obliquebanded leaf roller *(Choristoneura roseaceana)* | Oak | Heavy defoliation. | Marinette County |
| Orangestriped oakworm *(Anisota senatoria)* | Oak saplings | Defoliation. | Dane County |
| Pinkstriped oakworm *(Anisota virginiensis)* | Northern pin oak | Approx. 200 acres of heavy defoliation. | Douglas County |
| Spring frost damage | Scrub oak | Moderate damage. | Florence County |
| Two-lined chestnut borer *(Agrilus bilineatus)* | Northern pin oak | Pockets of heavy mortality powerline right-of-ways. | Burnett County |
| Walkingstick *(Diapheromera femorata)* | Northern pin oak | Scattered, light defoliation. | Douglas County |

**PINE**

| | | | |
|---|---|---|---|
| Armillaria root rot *(Armillaria mellea)* | Red and white pine | General decline and mortality. | Dunn, Eau Claire counties |
| Dook's needle blight *(Lophodermium spp.)* | White pine | Widespread discoloration and needle drop on individual white pine. | Bayfield, Burnett, Sawyer, Washburn counties |
| Eastern pine shoot borer *(Eucosma gloriola)* | Red pine | Lateral shoots and branches twisted and distorted. Branches broke off easily where they were damaged. | Chippewa County |
| Ips bark beetles *(Ips* spp.) | Jack and red pine | Pockets of tree mortality. | Lincoln, Oneida counties |
| Ips bark beetles *(Ips spp)* | Red pine | Tree mortality. | Throughout West Central Region |
| Jack pine budworm *(Choristoneura pinus)* | Jack pine | Widespread, light defoliation with one small (<1000 acres) pocket of moderate defoliation. | Washburn County |
| Jack pine budworm *(Choristonuera pinus)* | Jack pine | No visible defoliation except in Adams and Juneau counties, where there were areas of moderate/heavy defoliation and high numbers of budworm. Egg mass survey indicates possible heavy defoliation in 1999. | Adams, Clark, Eau Claire, Jackson, Juneau, Monroe counties |
| Mound ants *(Formica exsectoides)* | White pine | Tree mortality. | Wood County |
| Pine needle midge *(Contarina baeri)* | Red pine | Approx. 1500 acres in two pockets. | Burnett, Washburn counties |
| Pine needle midge *(Contarinia baeri)* | Red pine | Needles bent at 90-degree angle inside fasicle. | Juneau County |
| Pine needlerust *(Coleosporium* spp.) | Red pine | High number of aecia on pine needles. | Vilas County |
| Pine root tip weevil *(Hylobius rhizophagus)* | Red pine | Scattered branch mortality in trees. | Adams County |

| | | | |
|---|---|---|---|
| Red pine decline | Red pine | Symptoms of pocket decline, but also road salt injury. Problem with high water at times and Armillaria root rot is present. | Dunn County |
| Red pine pocket decline | Red pine | Dead trees in center with declining trees around edge. | Clark, Trempealeau, Wood counties |
| Red pine shoot moth *(Dioryctria resinossella)* | Red pine | Widespread tip flagging. | Burnett, Douglas, Washburn counties |
| Red pine shoot moth *(Dioryctria resinosella)* | Red pine | Light to moderate shoot damage. | Columbia County |
| Red pine shoot moth *(Dioryctria resinossella)* | Red pine | Lateral branch shoot mortality. Trees set new buds behind dead shoot. | Chippewa County |
| Sphaeropsis collar rot and shoot blight *(Sphaeropsis sapinea)* | Jack, red, and white pine | Planted and/or natural regeneration dying. Staining under bark in trees up to 10 years old. | Eau Claire, Jackson, Marathon counties |
| Sphaeropsis shoot blight *(Sphaeropsis sapinea)* | Red pine | Shoot mortality and branch flagging. | Chippewa County |
| Sphaeropsis shoot blight *(Sphaeropsis sapinea)* | Jack pine | Overall chlorosis of crown in pines approx. 40 years old. | Clark County |
| White pine blister rust *(Cronartium ribicola)* | White pine | Found blister rust fruiting on branch, however, branch was still green and alive in Clark County. General decline leading to mortality. | Clark, Dunn, St. Croix, Wood counties |
| Zimmerman pine moth *(Dioryctria zimmermanni)* | Red pine | Branch mortality and damage to main stem. | Chippewa County |

**SPRUCE**

| | | | |
|---|---|---|---|
| Cytospora canker (*Leucostoma kunzei*) | Spruce | Branch cankers and dieback on urban trees. | Lincoln County |
| Rhizosphaera needlecast (*Rhizosphaera kalkhoffii*) | Spruce | Severe needle discoloration and cast. | Lincoln County |
| Spruce budworm *(Choristoneura fumiferana)* | White spruce | Moderate defoliation of plantations. | Washburn County |
| Spruce budworm *(Choristoneura fumiferana)* | White spruce | Light-moderate defoliation. Egg mass survey indicates possible heavy defoliation in 1999. | Marathon County |
| Yellow-headed spruce sawfly (*Pikonema alaskensis*) | Spruce | Moderate to severe damage on individual trees. | Iron, Lincoln counties |
| Yellow-headed spruce sawfly *(Pikonema alaskensis)* | White spruce | Scattered, moderate defoliation of open-grown spruce. | Bayfield, Sawyer, Washburn counties |

**TAMARACK**

| | | | |
|---|---|---|---|
| Larch casebearer (*Coleophora laricella*) | Tamarack | Moderate to severe defoliation. | Oneida County |

**WALNUT**

| | | | |
|---|---|---|---|
| Fall webworm *(Hyphantria cunea)* | Black walnut | Moderate to heavy defoliation. | Columbia County |
| Pecan leaf casebearer *(Acrobasis juglandis)* | Black walnut | Bud and shoot damage. | Dodge, Grant counties |

**WILLOW**

| | | | |
|---|---|---|---|
| Imported willow leaf beetle *(Plagiodera versicolora)* | Willow | Moderate to severe damage. | Langlade, Lincoln counties |

# Appendix A - Model Oak Wilt Ordinance

TO: Recipients of Model Oak Wilt Ordinance

FROM: Community Oak Wilt Prevention Committee

SUBJECT: Purpose and Suggestions for use of Model Oak Wilt Ordinance

Thank you for showing interest in prevention and management of oak wilt. This disease is currently present in the southern 2/3 of Wisconsin and threatens the health of Wisconsin's oak resource. Oak wilt is particularly devastating once it becomes established in urban settings where oak trees dominate the landscape. Red, black and northern pin oak are particularly at risk as this disease kills these species quickly.

This model ordinance contains basic information necessary for implementing a policy that will help communities prevent and manage oak wilt. While the technical information in this ordinance should not be changed, the procedures for staff implementation, enforcement and requirements can be tailored to a community's specific needs. If you are interested in receiving assistance with tailoring this ordinance to fit your community's needs, contact your Department of Natural Resources Regional Urban Forestry Coordinator.

# OAK WILT ORDINANCE - a model[2]
## 9/9/98

**1. Declaration of Policy**

The city/village/town/county has determined that the health of oak trees within the municipal limits is threatened by the fatal disease known as oak wilt. Such hazardous conditions resulting from the spread of the disease create the potential danger of windfall or other breakage of significantly weakened/dead standing trees situated in the vicinity of common property boundaries or common travel lanes. It has further been determined that the loss of oak trees growing upon private and public property would substantially depreciate the value of property within the city/village/town/county and impair the safety, good order, general welfare and convenience of the public. It is declared to be the intention of the Council to prevent and control the spread of oak wilt and this ordinance is enacted for that purpose.

**2. Designation of a Tree Disease Control Area**

The Council shall designate an oak wilt control area within the city/village/town/county in which this oak wilt ordinance and control procedures shall be enacted.

**3. Appointment of Tree Inspector**

The position of tree inspector is hearby created within the city/village/town/county. It is the duty of the tree inspector to coordinate, under the direction of the Council, all activities of the municipality relating to the prevention and control of oak wilt and other epidemic diseases of shade trees.

**4. Nuisances Declared**

The following are declared to be public nuisances whenever and wherever they may be found within the designated oak wilt control areas.

a) Any living or standing tree or part thereof in the red oak group such as red oak, pin oak, scarlet oak and black oak colonized to any degree with the oak wilt fungus, *Ceratocystis fagacearum*.

b) Also, any living or standing tree in the white oak group such as white oak, bur oak and bicolor oak, colonized to any degree by the oak wilt fungus, that poses a threat of transmission of the oak wilt fungus to other trees of the same species through interconnected root systems.

c) Nuisances will also include any parts of colonized oaks that do not have bark removed, including logs, branches, stumps and firewood.

**5. Abatement**

It is unlawful for any person to permit any public nuisances as defined to remain on any premises owned or controlled by that person within the designated control areas. Such nuisances may be abated in the manner prescribed by this ordinance.

**6. Inspection Procedures**

a) Annual Inspection: The tree inspector or his/her duly appointed agents shall survey the designated oak wilt control area of the city/village/town/county to determine whether any conditions described in the **Nuisances Declared** section of this ordinance exist.[3] The tree inspector shall, in addition, conduct emergency inspections whenever deemed necessary and take action as authorized in this ordinance.

b) Entry upon Private Premises: The tree inspector so designated by the Council or his/her duly appointed agents may enter upon private premises at any reasonable time for the purpose of carrying out the duties assigned to him/her in this ordinance. Before making any inspection on private property within the city/village/town/county, the tree inspector shall give oral or written notice of said inspection to all affected residents and property owners, or by publishing said notice in a local paper of general circulation. Oral or written notices that an inspection has been completed on private property shall be given to the homeowner or left at said residence.

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2 Developed by the Community Oak Wilt Prevention Committee, an ad hoc committee of the Wisconsin Arborist Association.

3 In Wisconsin, symptoms of oak wilt are most commonly observed from mid-June through July; surveys should be conducted during this period.

c) Diagnosis: The tree inspector shall whenever possible, upon finding indications of oak wilt, make a diagnosis based upon accepted field symptoms and if deemed necessary, will deliver appropriate samples or specimens for laboratory analysis.[4]

**7. Interference Prohibited**

It is unlawful for any person to prevent, delay or interfere with the city/village/town/county tree inspector or his/her agents in the performance of duties imposed by this ordinance.

**8. Notices Following Inspection**

If the tree inspector finds evidence of oak wilt infection or the potential for infection of other trees, he/she shall notify, by certified mail, the owner of the property on which the nuisance is found. Said notice shall contain the survey information with respect to the subject trees on the property. Such notice shall describe the nuisance and recommend procedures for its abatement within a period of time specified by the inspector. The notice shall further state that unless the owner shall abate the nuisance in the manner specified, or appear at a hearing to show that such a nuisance does not exist or does not endanger the health of other trees, the tree inspector may cause the abatement thereof at the expense of the property served. The tree inspector reserves the right to extend abatement procedures under difficult circumstances of compliance. If the owner cannot be found, such notice shall be given by publication in a newspaper of general circulation in the town. After the expiration of the time specified by said notice, the tree inspector may proceed to abate the nuisance as herein provided. The cost of such abatement, shall be assessed against the owner of the property involved, or against the property itself.

Any owner of real estate in the control area, who receives any notice as provided herein, may request that the tree inspector obtain a laboratory diagnosis of oak wilt of one or more of such trees. Such a request shall be made to the tree inspector within five (5) days after the date of such notice.

**9. Responsibility for Abatement**

PRIVATE LANDOWNER - An owner thus notified of the existence on his/her property of a nuisance as described in this ordinance shall abate or direct the abatement of the nuisance within the specified time indicated on this notice. The abatement of nuisances and disposal of all associated materials shall be done in a manner satisfactory with the tree inspector, so as to ensure the elimination of the nuisance.

JURISDICTIONAL ABATEMENT - If the private landowner does not initiate abatement procedures in the specified time, the tree inspector may then proceed to contract for the prescribed abatement procedure as soon as possible and shall report to the city/village/town/county clerk all charges resulting from the abatement procedures. The clerk shall list all such charges along with additional administrative costs as determined in this ordinance against each separate lot or parcel as a special assessment to be collected commencing with the following year's taxes.

**10. Prevention of Spread**

In efforts to control overland spread of oak wilt, pruning, cutting or other wounding of oaks is prohibited from April 15 until July 1 without a written permit. (Ongoing research may extend these dates). During this period (April 15 until July 1) if wounding occurs or pruning is necessary in response to an emergency, a tree wound dressing shall be applied immediately to each wound. The cut surface of stumps from living-noninfected oaks shall be immediately painted with a tree wound dressing.

**11. Corrective Measures for Abatement of Nuisances**

Because oak wilt is a community problem and because oak wilt control may benefit an entire neighborhood, the tree inspector shall recommend and encourage neighborhood participation and cooperation, including cost sharing, in root graft disruption and other control efforts, especially where oak wilt is in danger of spreading across property boundaries.

Any diseased material to be used as fuel wood or to be salvaged for other purposes must be debarked or else

4 Samples should be collected from trees with wilting leaves; good samples are branches, ½ - 1" in diameter, with attached, wilting leaves.

completely covered by heavy plastic (minimum of 4 mil) for a period of time as indicated by the tree inspector. Stumps of infected trees shall be removed or debarked to ground-line in a time frame designated by the tree inspector, to eliminate all possibilities of formation of fungal mats and overland spread by insects. Any branch greater than 2" in diameter determined by the tree inspector to be hazardous and not salvaged shall be disposed of by burning, chipping, or removal to an authorized dump site in a time frame designated by the tree inspector. Dead standing red oaks that have advanced beyond the potential for spore production need not be removed except where they constitute a hazard to life and/or property. The tree inspector will advise accordingly.

Trees of the red oak group diagnosed as having oak wilt may be girdled as directed by the tree inspector as soon as infection is detected in order to speed drying and reduce spore formation. Girdling should not be performed on trees that are or could be grafted to other healthy oaks (this practice can hasten root-graft spread of the fungus). The tree inspector also may apply any registered silvicide to hasten death and drying of infected trees. Girdling shall be done only in areas where a resulting, weakened tree will not constitute a hazard to life and/or property should it fall. Nuisance abatement of trees in the white oak group may be accomplished through removal of infected parts.

**12. Transporting Wood Prohibited**

It is unlawful for any person to transport, into, within or through the control area, any diseased wood that has been determined to be a nuisance as described in the previous sections, without having obtained a permit from the tree inspector. Such permits shall only be granted when the purposes of this ordinance will be served thereby.

**13. Permit Procedure**

Any person seeking a permit to trim, cut, prune or otherwise wound (e.g. cabling) any oak tree(s) in the control area between April 15 and July 1, or transport diseased trees or parts thereof shall request a permit from the tree inspector.

**14. Tree and Woodland Preservation**

Individuals/developers proposing construction in areas with one or more oak trees are required to schedule an on-site inspection with the tree inspector to develop a plan to protect oaks from infection.

**15. Penalties**

A violator of this ordinance shall upon conviction thereof forfeit not less than $50.00 nor more than $5,000.00 together with the costs of prosecution as allowed. Each violation is considered a separate offense.

**16. Enforcement by Citation**

This ordinance may be enforced by citation in lieu of the penalties as listed above. Any designated city enforcement officer may issue citations. The schedule of deposits for violation of this ordinance are as follows:

| | |
|---|---|
| 1st violation (within 3 years) | $75 plus court costs |
| 2nd violation (within 3 years) | $125 plus court costs |

An additional $25 for each tree directly involved in the violation will be added. Each day such violation continues shall be continued as a separate offense.

**17. Transfer of Property**

At the time of sale or transfer of real property, the grantor(s) or his/her agent bears the affirmative obligation to disclose the terms of this ordinance regulation to the grantee(s).

**18. Severability**

If any section, subsection, sentence, clause or phrase of this ordinance is for any reason held to be invalid or unconstitutional by reason of any decision of any court of competent jurisdiction, such decision will not affect the validity of any other section, subsection, sentence, clause, phrase or portion thereof irrespective of the fact that any one or more sections, subsections, sentences, clauses, phrases or portions thereof may be declared invalid or unconstitutional.

**Date of Effect and Signatures**

# Appendix B - Jack Pine Budworm Survey Procedures & 1998 Survey Results

(Shane Weber, DNR Forest Entomologist, Spooner, WI)

**Jack pine budworm early larval survey**

This survey is done on a yearly basis and is a key indication of the presence of destructive budworm populations. Thirty shoots and staminate flowers (15 of each) that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce some years, a majority of shoots are usually used. A count of 20 or more infested shoots and flowers is considered sufficient enough to cause moderate to severe defoliation.

| 1998<br>JACK PINE BUDWORM - EARLY LARVAL POPULATIONS | | | | | |
|---|---|---|---|---|---|
| COUNTY | # PLOTS | # INFESTED SHOOTS | # INFESTED SHOOTS/PLOT | # HIGH PLOTS | % HIGH PLOTS |
| Polk | 15 | 10 | 0.67 | 0 | 0 |
| Burnett | 24 | 35 | 1.46 | 1 | 4.2 |
| Washburn | 21 | 150 | 7.14 | 6 | 28.6 |
| Douglas | 54 | 704 | 13.03 | 44 | 81.5 |
| Bayfield | 32 | 239 | 7.47 | 8 | 25.0 |
| | | | | | |
| Region | 146 | 1138 | 7.79 | 59 | 40.4 |

| 1998<br>JACK PINE BUDWORM – EARLY LARVAL POPULATION TRENDS | | | | | | | |
|---|---|---|---|---|---|---|---|
| | # INFESTED SHOOTS/PLOT | | | | % OF HIGH PLOTS | | |
| COUNTY | 1996 | 1997 | 1998 | % CHANGE(97-98) | 1996 | 1997 | 1998 |
| Polk | 1.27 | 0.93 | 0.67 | -28 | 0 | 0 | 0 |
| Burnett | 1.43 | 0.78 | 1.46 | +87 | 0 | 0 | 4.2 |
| Washburn | 1.55 | 1.90 | 7.14 | +275 | 0 | 5.0 | 28.6 |
| Douglas | 5.21 | 10.84 | 13.03 | +20 | 18.9 | 60.8 | 81.5 |
| Bayfield | 6.89 | 13.43 | 7.47 | -44 | 22.2 | 67.9 | 25.0 |
| | | | | | | | |
| Region | 3.95 | 7.29 | 7.79 | +7 | 11.6 | 37.2 | 40.4 |

**Jack pine budworm pupal survey**

Again, this survey is conducted on a yearly basis and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupae cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in five minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time it took to find 25 pupae is then recorded. Later, adults, parasites, and non-emergence is recorded for each pupae.

1998
JACK PINE BUDWORM - PUPAL SURVEY

| | | | | MOTHS | | PARASITES | | NON-EMERGED | |
|---|---|---|---|---|---|---|---|---|---|
| COUNTY | TOTAL PUPAE | TOTAL MINUTES | PUPAE/MIN | # | % | # | % | # | % |
| Polk | 35 | 95 | 0.37 | 21 | 60.0 | 11 | 31.4 | 3 | 8.6 |
| Burnett | 52 | 135 | 0.39 | 31 | 59.6 | 15 | 28.8 | 6 | 11.6 |
| Washburn | 256 | 176 | 1.45 | 134 | 52.3 | 91 | 35.5 | 31 | 12.2 |
| Douglas | 690 | 532 | 1.30 | 341 | 49.4 | 287 | 41.6 | 62 | 9.0 |
| Bayfield | 260 | 264 | 0.98 | 120 | 46.2 | 125 | 48.1 | 15 | 5.7 |
| | | | | | | | | | |
| Region | 1293 | 1202 | 1.08 | 647 | 50.0 | 529 | 40.9 | 117 | 9.1 |

1998
JACK PINE BUDWORM - PARASITE & PREDATOR COMPLEX

| | TOTAL | % OF PARASITIZED | % OF TOTAL |
|---|---|---|---|
| Itoplectes | 115 | 21.7 | 8.9 |
| Scambus | 27 | 5.1 | 2.1 |
| Phaogenes | 116 | 21.9 | 9.0 |
| Agrypon | 1 | 0.2 | 0.1 |
| Pteromalids | 65 | 12.3 | 5.0 |
| Tachinids | 98 | 18.5 | 7.6 |
| Predators | 107 | 20.3 | 8.3 |

1998
JACK PINE BUDWORM – PUPAL POPULATION TRENDS

| COUNTY | 1996 PUPAE/MIN | 1997 PUPAE/MIN | 1998 PUPAE/MIN | % CHANGE 97-98 |
|---|---|---|---|---|
| Polk | 0.13 | 0.03 | 0.37 | + 1,233 |
| Burnett | 0.07 | 0.06 | 0.39 | + 650 |
| Washburn | 0.16 | 0.62 | 1.45 | + 234 |
| Douglas | 1.34 | 1.60 | 1.30 | - 19 |
| Bayfield | 1.26 | 1.37 | 0.98 | - 28 |
| | | | | |
| Region | 0.91 | 1.10 | 1.08 | - 2 |

## Appendix C - Habitat Type and the Incidence of White Pine Blister Rust in Northern Wisconsin

(Sally Dahir, DNR Forest Health Protection, Madison, WI)

### Introduction

I had the unique opportunity this summer to discuss opinions on the role of blister rust in our reticence to plant white pine in northern Wisconsin. Talking to both new and seasoned foresters, I got the sense of a distinct difference in their awareness of blister rust as a threat to white pine. One man who had worked along side the ribes eradication crews in the 1950's and 1960's (a USDA program to eliminate blister rust by destroying its alternate host, ribes or gooseberry), felt that blister rust, although far less a presence in today's aging white pine stands, was still around and would likely experience a revival if ever we undertook large scale planting programs. Most of the younger foresters, who certainly hadn't been practicing in the 1960's, had only rarely seen a canker and were much more open to reviving white pine both as a commercial species and as an integral part of Wisconsin's landscape. With a stronger background in environmental studies and an awareness of the increasing public demand to restore old-growth ecosystems, they realized the ecological importance of reviving species such as hemlock and white pine that had once dominated the landscape of pre-settlement Wisconsin.

White pine indeed was once the king of lumber species in the northeast and the Lake States, credited for "the Masting (of) Her Majesties Navy" as early as 1609. It was so valuable for the maintenance and repair of British ships, that the removal of mast trees by the colonists is said to have played an important role in the defeat of the British during the Revolutionary War. After the depletion of old-growth white pine in New England in the 1830's, logging was shifted to the Lake States and, by 1875, the resource had virtually disappeared here as well. Today we have a total of 96,000 acres in the white pine forest type in the northern half of Wisconsin with only 2,200 acres in seedling-sapling stands, less than 2.5% of the total. We have 16,400 acres in white pine plantations in northern Wisconsin (Schmidt 1997), only 900 acres planted since 1965. This is only 5.5% of the 296,000 total acres planted in red pine. One of the principal reasons we have emphasized red pine over white pine production is the commonly held belief that red pine has fewer problems. Although significantly affected by deer browse and white pine weevil, the arrival of blister rust in Wisconsin in 1915 was probably the largest deterrent to large scale planting of white pine. However, recent research has shown that the magnitude of the threat of blister rust can vary a great deal from one site to the next. This is true both on a regional scale, favoring the cooler and damper climate of northern Wisconsin over the southern half of the state, and on a local level, demonstrating greater pathogenicity in certain topographic locations and under specific microclimatic conditions.

This distribution is in large part determined by the specific germination and survival requirements of the infecting basidiospore, i.e. a minimum of 48 hours of cool temperatures (< 68° F) and saturated air. A comparison of these requirements with meteorological data from across Wisconsin forms the basis of blister rust hazard zone mapping. Van Arsdel (1968) divided the state into 4 risk or hazard zones with the area of highest risk covering most of northern Wisconsin. In the 1950's and 1960's this zone was thought to carry a ubiquitously high risk for planting white pine and land managers were cautioned to expect losses to blister rust of up to 25% of their stand regardless of site factors or silvicultural practices (Van Arsdel 1968).

Several studies, however, have found that risk zone 4 is not at all homogeneous with respect to high incidence of blister rust. For instance, King (1958) reported an average incidence of infection of only 4.5% in seedlings stands in the high hazard zone of northern Wisconsin. In addition, he reported a great deal of variability between sites (0-44%) and very little correlation between infection levels and local ribes population. Several recent studies in high risk areas of the Lake States have shown levels of infection that were much lower than expected. For instance, Robbins et al. (1988) surveyed white pine sapling stands in the Upper Peninsula of Michigan and found an average incidence of infection of only 1.5%. In addition, they reported no statistical correlation with local site factors or geographic hazard zone. Working in underplanted white pine stands in Minnesota, Sauerman (1992) reported that over 90% of stands showed no sign of infection at all. Work in Wisconsin as well, on the Nicolet and Chequamegon National Forests has also yielded much lower results than expected. Mielke et al. (1990) reported that only 7% and 6%, respectively, of all seedlings on the 2 forests were infected, with annual infection rates averaging 1.87% and 1.55%. In addition to reporting very low rates of infection, these researchers emphasize the importance of considering local site factors in determining the risk of blister rust to young white pine.

These recent studies, however, are limited to seedling and sapling size classes and do not give us much information on the role of blister rust in the majority of our white pine acreage, over 97% of which is in pole and sawtimber stands. To

date, we have only a few studies on the effect of blister rust on older trees. Some research has shown that blister rust may be less pathogenic in older white pine. For instance, Patton (1961) reported that the rate of infection to grafting decreased proportionally as tree age increased. Cankers in older trees also may grow more slowly, both vertically on the stem and around the bole (Phelps and Weber 1969). Given the larger circumference of older trees, girdling would be much slower and mortality rates lower. Older trees also demonstrate a higher rate of canker inactivation (lack of sporulation) both for bole cankers (Phelps and Weber 1969) and branch cankers (Kimmey 1969, Hungerford 1977). Although, we might assume from this research that the incidence of blister rust would be lower in older stands, there has been no research documenting the incidence of rust in stands past the seedling-sapling stage.

In order to determine the current status of blister rust in northern Wisconsin, it's essential not only to report the incidence of blister rust in older stands, but also to investigate more closely the relationship between site factors and the severity of infection. Although several studies have recognized that the observed variability between stands is probably due to site factors, none have either investigated this relationship or been able to find any significance. The objectives of this study were: 1) to report the incidence of white pine blister rust in large pole to small sawtimber stands in risk zone 4 of northern Wisconsin and 2) to investigate the relationship, if any, between site factors and the intensity of rust infection.

**Methods**

A total of 61 stands were surveyed in nine counties in risk zone 4 (Figure 1). A minimum of three randomly located, 10-factor prism plots were established in each stand. Plots were separated by a minimum of three chains and stratified across a range of topographic position and slope.

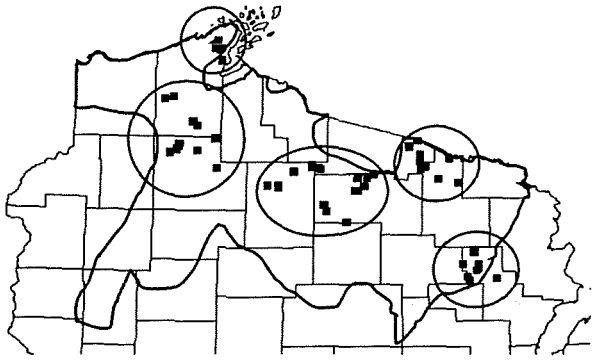

Figure 1. A total of 61 stands were surveyed, 59 within in Risk Zone 4 (shaded yellow). Study areas were divided into 5egions based on geographic proximity.

Figure 2. Typical blister rust canker with profuse pitch production and narrowing of bole.

Site factors that were analyzed included slope, aspect, topographic position, habitat type and the presence/absence of ribes. Species, diameter at breast height and crown class were recorded for all *in* trees. Lastly, all white pines were surveyed for bole cankers and, where present, the height on the bole was noted. Minimum criteria for classifying a stem anomaly as a canker included 1) profuse pitch production and 2) stem deformity in the same area, usually narrowing (Figure 2).

**Results and Discussion**

The incidence of blister rust averaged 7.2% across all sites and 5.9% excluding Bayfield County which averaged 15.9% (Figure 3). As indicated by the map below, the further northwest the location of the stand, i.e. the closer to Lake Superior, the higher the level of infection. Also, incidence increased with elevation. Other site factors that showed significant positive correlation with the incidence of rust were northerly aspect, and wetter, more mesic habitat type. Stand characteristics significantly correlated with a lower incidence included the presence of a hardwood overstory and a high total tree density or basal area.

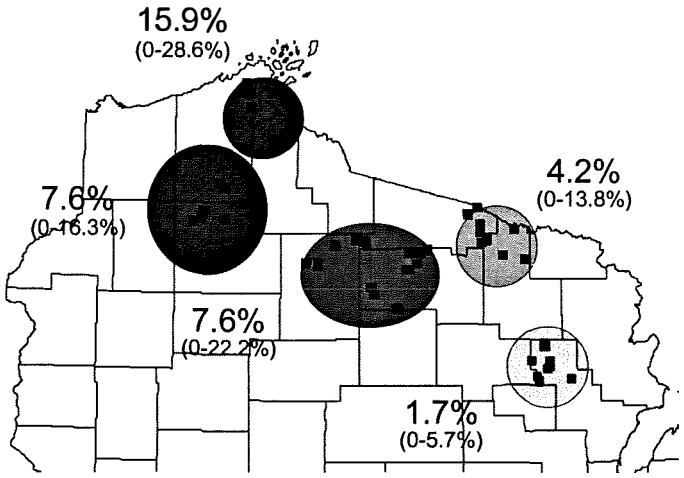


Figure 3. Average incidence by region. The range of incidences across all stands within each region is given in parentheses.

Discussion of these factors must be undertaken in light of what we know about the physiology of *Cronartium ribicol*a, the obligate fungal parasite that causes blister rust. Of the four spore stages of this fungus, successful infection hinges upon the precarious survival and germination of the basidiospore. Nocturnally transmitted, once this delicate spore leaves a ribes leaf, it must arrive and germinate on a live white pine needle in the same night. It is at this stage that site and stand factors exert the greatest influence on the likelihood of successful infection. This can occur in two ways: either by influencing the probability that a rust spore will actually land on a live white pine needle or by influencing the probability that the necessary requirements for spore survival (see above) will be maintained for at least 48 hours.

Prior to the 1950's, it was assumed that ribes spores were easily transmitted to live pine needles and by eliminating the alternate host from within 900 feet of the stand, the possibility of transmission was eliminated. However, King (1958) noticed that high levels of rust occurred in stands with very few ribes bushes in the vicinity, inferring long distance spread of spores. Subsequent research by Van Arsdel (1967) demonstrated that spores were often carried long distance by nocturnal winds and it was the direction of these air currents that in some areas determined where the delicate basidiospores landed and where infection occurred. For instance, Bayfield peninsula presents a unique situation for the spread of blister rust. Not only is it surrounded by water on three sides, but the entire coastal plain is dominated by heavy alkaline clays which are optimum habitat for several species of ribes. In the evening, as the land mass of the peninsula cools more rapidly than the surrounding water, nocturnal winds flow from land toward water. As these winds cross the shoreline, they pick up rust spores from the ribes and carry them out over the water. This air gradually warms up, rises, and flows back inland, depositing spores on hilltops 5 to 10 miles inland, far from the nearest ribes plant (Figure 4). Van Arsdel noted that white pines growing on these hilltops were devastated by rust, whereas pine growing near the coastal plain were relatively uninfected.

Van Arsdel observed a similar phenomenon in other parts of northern Wisconsin. In these areas of typical glacial topography, white pine is found mostly in sandy upland forests, while ribes tends to grow in the alkaline, organic soils of adjacent pothole and lake shore areas. Here cool evening air flows downslope into the lowland area, where it picks up rust spores from ribes, is displaced by incoming air and circles back to drop these spores on upland pines over 2,000 feet away from the nearest ribes bush. Again, he noted that white pines in these higher locations were more heavily infected than pines growing at lower elevations.

Figure 4. Nocturnal air currents carry basidiospores away from lowland areas and drop them on white pine growing in upland forest (Anderson 1973).

Our results corroborated Van Arsdel's research in finding both a much higher incidence of infection on Bayfield peninsula than in other areas of risk zone 4 and in observing a significant positive correlation between infection levels and elevation. White pine growing on ridgetops and shoulders had an average 12.3% incidence of cankers, whereas 7.4% of trees on mid and lower slopes and 4.7% of trees on bottomland were infected. This correlation between topographic position and incidence of infection was significant in all regions and on all habitat types.

The presence of a hardwood overstory, which was correlated with low incidence of infection, affects the probability of spores landing on live pine needles and the microclimate surrounding these needles. The presence of an overtopping canopy acts as a protective blanket, intercepting rust spores which fall out of the atmosphere and preventing dew formation on understory trees. White pine needles tend to stay drier and warmer, conditions that diminish the survivability of basidiospores.

Basidiospore survival was also diminished by the presence of a high tree density. At an individual tree level, a higher density of trees means that each tree will have a smaller crown or target area and, therefore, a lower probability of intercepting a single spore. Also, pole to sawtimber-sized trees at high densities will have crowns located higher on the bole with few branches at ground level. Dew is much less likely to remain on needles at 40 to 50 feet in the air than on live branches close to the ground where cool, damp conditions will persist for a longer period throughout the day. Both northern longitude and a northerly aspect, which showed significant positive correlation with incidence rates, affect microclimatic conditions primarily. Northern locations, especially near Lake Superior, will be cooler and more humid, as will northerly aspects.

Habitat type was related to rust levels only on Bayfield Peninsula. There were three dominant habitat types in Bayfield County, AbArSm (Abies-Arisaema Smilacina), ArQV-Sm (Acer rubrum- Quercus /Vaccinium-Smilacina), PMV-Po (Pinus Maianthemum Vaccinium-Polygonatum), and 4 types on other sites, ArQV (Acer rubrum- Quercus /Vaccinium), PMV (Pinus Maianthemum Vaccinium), ATM (Acer-Tsuga Maianthemum), and TMC (Tsuga/Maianthemum-Coptis). Types which included less than 5% of all plots were not included in the analysis. All of the habitat types on Bayfield Peninsula showed higher than average incidence of rust compared to equivalent types elsewhere, with peak incidence occurring on the wettest type, AbArSm, and declining as the moisture-nutrient level of the type decreased (AbArSm (22.7%) > PMV-Po (12.3%) > ArQV-Sm (9.9%)). This was significant at $p$=0.05 (F=3.5, df=21,MSE=112.6).

A somewhat different relationship was observed outside Bayfield Peninsula, which due to lack of statistical significance only represents a trend. In most of northern Wisconsin dry to dry-mesic types demonstrated the highest average incidence of rust (PMV -7.7%, AQV - 7.6%) and the mesic type, ATM, showed a much lower incidence of only 5.1% . Mean disease incidence on TMC (5.0%), a very wet nutrient-poor habitat type occurring mainly in the transition zone from lowland to forest, also had a lower than average incidence of rust. This may partly be due to the phenomenon observed by Van Arsdel (see Figure 4) in which nocturnal air currents carry spores away from lowland sites where TMC

occurs and deposit them on pines growing in upland sites.

Almost no ribes plants, the alternate host to blister rust, were observed on our study areas. Found almost exclusively on nutrient-rich and/or wet sites in northern Wisconsin, ribes is rarely, if ever, found on dry to dry-mesic habitat types which represented the majority of our study sites. In the Habitat Type Guide for Northern Wisconsin (Kotar, et al. 1988), ribes is not listed as a significant species for either PMV or ArQV, representing <20% incidence. The only possible explanation for the occurrence of rust in these stands is long distance transmission of spores from ribes bushes growing in neighboring lowland areas which, as explained earlier, may commonly occur in northern Wisconsin

The incidence of rust is still unknown in more mesic sites where ribes incidence is typically quite high (Kotar et al. 1988). The fairly low incidence of blister rust cankers which we observed may be an artifact of sampling areas where ribes does not naturally occur. Before any conclusions can be drawn about the necessity or efficacy of ribes eradication as a blister rust control mechanism, research must be done in areas of high ribes occurrence and coverage. This might include typical northern hardwood stands on mesic habitat types such as AViO, ACaCi, and AH. Though white pine does not often occur in pure stands on these sites, sampling stands under a hardwood overstory or white pine stands growing in proximity to these types would help to elucidate this relationship.Although almost no ribes were observed on our study areas, as explained earlier short distance transmission of spores from neighboring low areas may commonly occur in northern Wisconsin.

Although, several dry to dry-mesic habitat types were observed in this study, the incidence of rust is still unknown in more mesic sites where ribes incidence is typically quite high (Kotar et al. 1988). The low incidence of blister rust cankers that we observed may be an artifact of sampling areas where ribes does not occur. The relationship of habitat type and rust severity needs to be investigated in areas of higher risk by sampling typical northern hardwood areas where ribes presence is common, i.e. mesic types such as AViO, ACaCi, and AH. Though white pine does not often occur in pure stands on these sites, sampling stands under a hardwood overstory or white pine stands growing in proximity to these types would help to elucidate this relationship.

In conclusion, the average incidence of infection in older stands reported in this study was similar to that reported by Mielke et al. (1990). Since older white pine are both less susceptible to infection and, once infected, tend to survive much longer than seedlings, we might speculate that both the rate of infection and the rate of mortality due to rust would also be lower in older age classes. Despite low overall incidence of infection, we observed a significant relationship between the incidence of rust and several site and stand characteristics. However, we can not hypothesize from this study whether these same relationships would hold in seedling/sapling stands where rust could be far more devastating. Since we had no indication of the history of rust incidence in the sampled stands, we have no way of knowing whether the trees presently occurring are genetically resistant and survived the disease or whether the stand was located in a site less conducive to rust infection. We also have little information on the incidence of ribes during the post-logging era. The clearing and subsequent hot fires may have created the optimum conditions for colonization of vast acreage by ribes bushes. Knowledge of initial stand conditions would be essential before any inferences could be made between our results and optimum site selection to avoid heavy rust infestations.

Though limited in scope, this study raises some very interesting questions regarding the current role of blister rust in high-risk areas of northern Wisconsin. Our results suggest the possibility that white pine could be grown more extensively in this area, however, further research is required to clarify the relationship between site factors and the incidence of blister rust in seedling plantations.

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# Appendix D - Insects and Pathogens Affecting Forest Health of Red Pine

Prof. Kenneth F. Raffa, Dept. of Entomology, UW – Madison

**Introduction**

Red pine plantations in Wisconsin are currently experiencing significant decline. The cause or causes of these losses are not understood. Most likely, there is no single causal agent. Instead, a variety of insects, fungi, and site factors interact, and the relative importance of these various factors varies among sites. However, the symptoms at the stand level exhibit a rather common pattern. Affected trees are often arranged in concentric patterns. Center-most trees are dead, and adjacent trees show crown thinning. Each year, these regions increase in radius. Thin - crowned trees die, and previously healthy trees show crown symptoms. These symptoms most commonly occur in stands that are pre-merchantable.

**Objectives**

The purpose of this research is to identify insects and pathogens associated with declining red pine stands, identify abiotic factors that favor their abundance and virulence, and develop monitoring methods for predicting the occurrence of potentially damaging species.

**Methods**

We established 17 plots throughout central and western Wisconsin. These plots included 9 declining sites, 4 control sites, and 4 control sites adjacent to declining sites. We conducted surveys of insect abundance, disease symptoms, and site factors.

Insects were surveyed using three types of traps: Baited (racemic ipsdienol & lanierone) multiple funnel pheromone traps (Wood 1982, Lindgren 1983, Raffa 1991), baited (+alpha pinene & ethanol) jug traps (Rieske & Raffa 1993), and baited (-alpha pinene & ethanol) pitfall traps (Hunt & Raffa. 1989). The first type of trap is aimed primarily at sampling bark beetles, wood borers, and predators. The second type of trap is designed to capture turpentine beetles and stem weevils. The third type is intended to capture root insects. Insects were sampled every 15 days.

Disease symptoms and pathogens were sampled using three methods. The first consisted of a systematic sampling of roots. At each of the 17 sites, 8 trees were sampled. Four were at the edge of the pocket margin, and 4 were in asymptomatic regions of the stand. Root tissue was collected from each tree, and isolations are being conducted. The main targets of this approach are *Leptographium* and *Armillaria*. The second method consisted of using red pine stem sections to sample *Heterobasidion annosum*. Five stem sections were deployed at each site, and at a site known to contain this pathogen. The third method consisted of excavation of plots, to allow for detailed examination of root tissue, adjacent to and distant from the root collar. This method is intended to allow for an opportunity to examine other possible causal agents.

Abiotic analyses include three methods. The first consists of mapping each site and collecting radial increment cores. We are examining possible correlations among pocket size, tree growth rates, tree relative growth rates, and mortality. The second method consists of collecting soil samples. These are being analyzed by the University of Wisconsin Soil and Plant Analysis Laboratory (Schulte et al. 1987.) for N, K, P, pH, soil texture, and % organic matter. The third approach consists of analyzing archival NOAA climatological data for possible relationships between weather and declining red pine stands. Some of the factors under consideration include minimum daily temperatures (with the possibility that high minimums could allow excessive evapotranspiration), and extremes in precipitation (which could lead to either drought or root flooding).

**Results**

We have completed two years of insect sampling. All of the insects from 1997 are identified, tabulated, and entered into computer databases. The analysis of the 1998 insect collections is still underway. The numbers of insects sampled were much higher for 1998, especially in jug and pitfall traps, because sampling could begin earlier, as the plot selection and establishment that needed to be completed during spring, 1997 were not needed in 1998.

The major stem colonizing insects were *Ips pini* (11,045), *Ips grandicollis* (3,050), and *Monochamus carolensis* (80). Thus, *I. pini* appears to be the most important insect in this group. Populations of Ips pini were highest in Buffalo Co., followed by Monroe Co., LaCrosse Co., and Chippewa Co. Populations of *Ips grandicollis* were highest in LaCrosse

Co. The most abundant predators were *Thanasimus dubius* (3086), *Platysoma cylindrica* (841), *Platysoma parallelum* (648), and *Enoclerus nigripes* (322). *Thanasimus dubius* populations were highest in LaCrosse Co. *Platysoma cylindrica* and *Platysoma parallelum* populations were also highest in LaCrosse Co. The major insects captured in jug traps were Ambrosia beetles (1879), *Pissodes nemorensis* (629), *Orthotomicus caelatus* (328), and *Dendroctonus valens* (195). Populations were highest in Chippewa Co. The major insects captured in pitfall traps were *Hylastes porculus* (1895), *Hylobius pales* (1321), *Hylobius radicis* (472) and *Hylobius rhizophagous* (155). *Hylastes porculus* was most abundant in Chippewa Co., and *Hylobius* weevils were most abundant in LaCrosse and Monroe Cos.

Root sampling was completed during August, 1998. Direct examination of roots indicated black-staining in association with root insects, but little else. Isolations from these specimens is underway. Red pine disks were deployed in November, 1998. *Heterobasidion* was isolated from the "positive control" plot near Coon Rock Rd. in Iowa Co. However, it was not isolated from any of the other stands. Three stands were excavated. Direct examination of the exposed roots did not reveal any signs or symptoms of disease that were different from observations made during the intensive sampling.

Soil samples were collected in July, 1998. These are currently being processed. Analysis of climatological data is underway.

**Conclusions**

Because the study is still underway, any conclusions must be treated as being preliminary. However, a few points seem to be emerging:

Various sections of the state show different patterns of various insect complexes.

The populations of predators of bark beetles may be important in reducing pest numbers, and hence in maintaining healthy red pine stands.

The major pathogens present appear to be *Leptographium*, in association with root insects. This agrees with previous observations by Raffa & Hall (1988), and Klepzig et al. (1991).
There is no evidence of widespread incidence of *Heterobasidion*. However, methods development needs further evaluation.

**Plans for 1999**

This study will be completed during 1999. Isolations, insect identifications, and soil analyses will be completed by April 1, 1999. Traps will be during before April 15. Sampling will be conducted from April 15 - September 1.

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**Appendix E - Monitoring Methods for Natural Enemies of Bark Beetle Pests**

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**Background**

Bark beetles in the genus *Ips* kill stressed trees through semiochemically mediated mass attack (1). Males select the host and produce pheromones, to which both sexes respond. *Ips pini* produce a chiral blend of (+/-) ipsdienol and a secondary component, lanierone (2, 3). Predators use *I. pini* pheromones as kairomones for prey location.

Pheromone based trap-out operations for bark beetles have had mixed success. While great numbers of pest beetles can be removed from an area, inadvertent trap-out of the predator complex may actually prolong outbreaks (4).

Recent work with *I. pini* and their predators has shown that they exhibit both a geographic and a temporal variation in response to chiral blends of ipsdienol and lanierone. In California, for example, pine engravers, *I. pini*, prefer a primarily (-) blend of ipsdienol with low lanierone levels; in Wisconsin, *I. pini* prefer a primarily (+) blend of ipsdienol with relatively high lanierone levels. Principle predators in California prefer (+) ipsdienol with lanierone characteristic of Wisconsin *I pini*, while Wisconsin predators prefer blends of predominantly (-) ipsdienol and show no preference for lanierone (5-7).

These response disparities provide us with some unique biocontrol opportunities. For instance, the response specificity could be used to sample the level of pests or predators in an area before designing a trap-out program. A subsequent trap-out program then could be targeted to remove the pests while leaving as much of the predator complex as possible.

**Objectives**

This study sought to characterize the response of *I. pini* and their predators to various ipsdienol / lanierone synthetic and natural pheromone blends for future potential applications of

(1) Population monitoring: Which synthetic lures most closely approximate pests/predators responding to a natural infestation?

(2) Trap-out: Which lures are most effective in removing the greatest amount of pests while leaving the beneficial predator complex?

(3) How do tree species and tree chemistry affect the above responses?

**Methods**

Choice Assay: Simulated Population Monitoring

A behavioral choice assay was conducted to determine which lure most closely approximates the natural guild of insects arriving at red pine colonized by *I. pini*. Insects were trapped in 50 year-old red pine plantation in central Wisconsin using 12-funnel Lindgren traps. Nine treatments were randomized along a line. The traps were randomized every 3 days for 6 sample periods. Treatments 1 - 6 consisted of 3 ratios of (+) and (-) ipsdienol, with and without lanierone. Treatment 7 consisted of a screened log infested with male *I. pini* emitting pheromones. Treatment 8 consisted of a screened control log, and treatment 9 was a blank control trap.

No-Choice Assay: Simulated Trap-Out

A no-choice assay was conducted to determine if high numbers of *I. pini* could be removed from a plantation while removing relatively few predators. Insects were trapped at 6 different isolated red pine plantations across central Wisconsin. Each plot had a block of 9 12-funnel Lindgren traps. At each plot, a different set of synthetic lures was deployed. The lures were rerandomized among plots every 4 days for 6 sample periods.

Effects of Tree Chemistry & Species

We developed a new system for assaying responses to bark beetles that is less cumbersome than previous work with logs and thereby allows superior replications. Tests were conducted in red, jack, and white pine stands in Sauk, Juneau, and Jackson Co., WI. We tested effects of host tree species on attraction of flying beetles to tunneling *I. pini*. Treatments consisted of white pine with *I. pini*, jack pine with *I. pini*, red pine with *I. pini*, white pine, jack pine, red pine, and blank control. This test was repeated in different forest types to determine if stand composition affected results.

We tested effects of host tree monoterpenes on attraction. Monoterpenes were tested alone, in combination with ipsdienol, in combination with ipsdienol + lanierone, and with ipsenol.

**Results**

Choice Assay: Simulated Population Monitoring

The insects caught in the highest numbers, *I. pini, Thanasimus dubius,* and *Platysoma cylindrica* (combined with *P. parallelum* as for analysis purposes), showed significant responses to the various treatments at $p<0.05\%$. *I. pini* prefer a blend of 50/50 to 75/25 (+/-)-ipsdienol in combination with lanierone. In contrast, *T. dubius* show strong preferences for the log infested with *I. pini.* Among synthetic lures, ipsdienol with a high (+) ipsdienol component was more attractant, and lanierone had no effect. Histerids strongly prefer mixtures of 03/97 (+/-)-ipsdienol.

No-Choice Assay: Simulated Trap-Out

Twenty insect species, including herbivores, predators, and parasites, were collected. Combined, more than 25,000 I. pini were removed from the plantation sites in two years (including Simulated Trap-Out & Population Monitoring

The insects caught in the greatest numbers, *I. pini, T. dubius,* and *P. cylindrica*, showed significant responses to the various treatments at $p<0.05\%$. *I. pini* preferred a blend of 50/50 (+/-)-ipsdienol with lanierone. *T. dubius* also prefer mostly (+) blends of ipsdienol, but as in the choice assay, show no synergistic response to lanierone. Histerids, as in the choice assay, were more attracted to (03/97) (+/-)-ipsdienol blends and this response was not synergized by lanierone

Effects of Tree Chemistry & Species:

Beetles boring in bark attracted 30 times more *I. pini* than other treatments ($P<0.0007$). Thus, this method provides a useful system for evaluating host species effects.

White pine in which *I. pini* were tunneling attracted more *I. pini*, *T. dubius*, and *P. cylindrica* than the other pine tree species. Red pine with *I. pini* attracted the least *I. pini*. However, the numbers of *T. dubius* and *P. cylindrica* did not vary between red and jack pines. Other species collected were *P. parallelum*, *Hylastes porculus*, *Hylobius pales*, *Hylobius radicis*, *Pachylobius* spp., several woodborer spp. and *Pissodes* spp. The separate study on forest type revealed no significant interactions-that is, the same result were observed whether the experiment was performed in a red, jack, or white pine forest.

No monoterpenes by themselves were attractive to *I. pini*, *T. dubius* or *P. cylindrica*. *Ips grandicollis* were attracted to (-)-alpha-pinene. *Dendroctonus valens* were attracted to traps baited with (±)-alpha-pinene, (-)-alpha-pinene, and delta-3-carene. *Hylastes porculus* were attracted to (-) alpha-pinene and (-)-beta-pinene. Four monoterpenes, (+)-alpha-pinene, (-)-alpha-pinene, (-)-beta-pinene and myrcene reduced the attraction of *I. pini* to Ipsdienol. None synergized attraction. Behavioral differences between prey and predators were again evident. Attraction of *T. dubius* was increased by (+)-alpha-pinene. Myrcene reduced attraction. Response of *P. cylindrica* was not affected. No terpene synergized *I. pini* responds to Ipsdienol with lanierone. (+)-alpha-pinene and myrcene inhibited responses. Predators of *I. pini* behaved differently than *I. pini*. Addition of (+) alpha-pinene attracted more *T. dubius* than Ipsdienol with lanierone alone. Myrcene inhibited responses.

More *P. cylindrica* were caught in traps baited with (+) alpha-pinene and Ipsdienol with lanierone than these pheromone alone. *Dendroctonus valens* were attracted to traps baited with delta-3-carene with Ipsdienol lanierone and (-)-beta-pinene with Ipsdienol and lanierone. *Hylastes porculus* showed the same response to all treatments, except myrcene, which had the lowest numbers of *H. porculus*. The interaction between (-)-alpha-pinene and Ipsenol appears to be synergistic. (-)-alpha-pinene increased the response of *T. dubius* to Ipsenol, and had no effect by itself.

**Conclusions**

(1) How Best to Obtain Good Sampling Estimates of the Related Numbers of Pests and Predators?

The pest:predator ratio for infested logs was 1.6 in spring and 7.3 in summer. Estimates of this ratio using synthetic lures varied widely with pheromone type, ranging from 0.2 - 18.5 in spring and 3.2 - 142 in summer. The best estimates were obtained using (50/50) (+/-) ipsdienol without lanierone and (03/97) (+/-) ipsdienol with lanierone. The former is far less costly and captures more *I. pini*, and so are most useful.

(2) How Best to Maximize Pest:Predator Ratios During Trap-out?

Two steps can be taken to minimize removal of predators while maintaining high trap-out: delaying deployment until summer, and using (75/25) (+/-) ipsdienol with lanierone. This approach can raise the desired ratio to 36.78, compared to 0.95 in a typical trap-out, which would use racemic (50/50) (+/-) ipsdienol without lanierone, starting in spring.
(3) Tree Species and tree terpenes affect responses:

White pine is more conducive to pheromonal attraction by *Ips pini* than red pine or jack pine.
The prey, *I. pini*, and the predators, *T. dubius*, and *P. cylindrica*, exhibited different responsive patterns. The interaction between Ipsdienol and monoterpenes on *I. pini response* was inhibitory. In contrast, the combination of some monoterpenes with Ipsdienol significantly increased trap catches of *T. dubius*.

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